NUEXCO

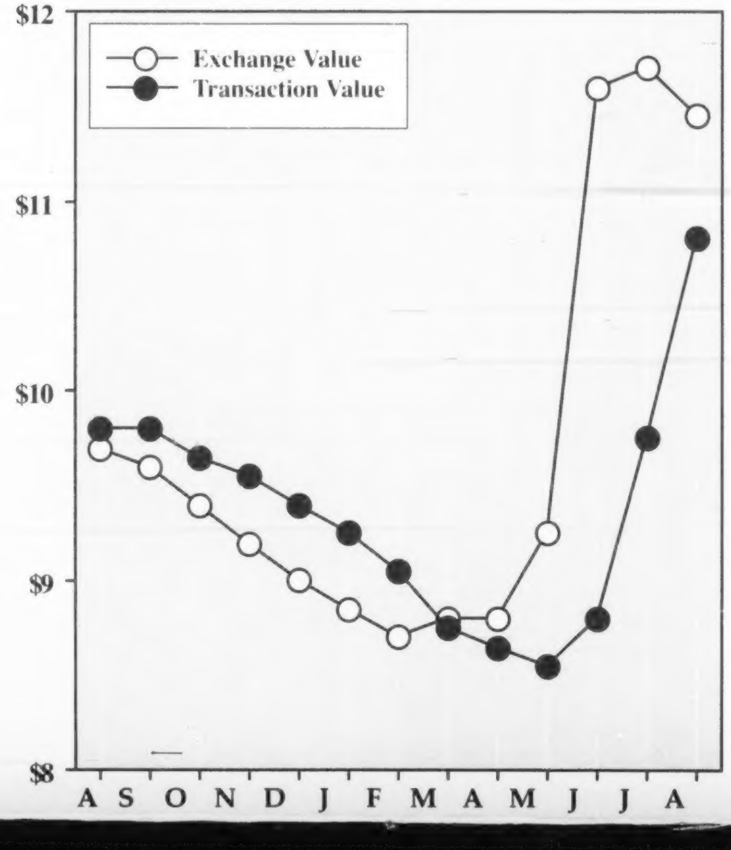
Monthly Report

September 1990 Number 265

Electrical Energy Alternatives and Their Effect on the Environment . . . 17

The Crow Butte Project Nears Production . . . 26

Czechoslovakia's Nuclear Power and Fuel Programs . . . 29



NUEXCO

INTERNATIONAL HEADQUARTERS

Oren L. Benton – Chairman and Chief Executive Officer
Earl E. Hoellen – President and Chief Operating Officer

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202 USA

Telephone: (303) 899-4500
Telefax: (303) 899-4555
Telex: 450202 (NUEXCO)

SERVICE LOCATIONS

DENVER, COLORADO, USA

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202
Telephone: (303) 899-4500
Telefax: (303) 899-4555
Telex: 450202 (NUEXCO)

SAN FRANCISCO, CALIFORNIA, USA

Building 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telefax: (415) 854-2115
Telex: 470674 (NUEXCO SF)

WASHINGTON, D.C., USA

11 Dupont Circle, Suite 505
Washington, D.C. 20036
Telephone: (202) 328-9250
Telefax: (202) 328-6699
Telex: 451691 (NUEXCO DC)

HONG KONG

1403 Shui On Centre
6-8 Harbour Road, Wanchai
Hong Kong
Telephone: (852) 865-1418
Telefax: (852) 865-2721
Telex: 67206 (CNITC)

ZURICH, SWITZERLAND

Leberngasse 15
4603 Olten
Switzerland
Telephone: (41-62) 320032
Telefax: (41-62) 321450
Telex: 981600 (NUXCH)

GENEVA, SWITZERLAND

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telefax: (33-50) 428526
Telex: 385288 (NUEXCO F)

SERVICE ENTITIES

NUEXCO Trading Corporation	Earl E. Hoellen, President
NUEXCO Information Services Company	Earl E. Hoellen, President
NUEXCO Transportation & Services Company ("NuTranS")	Robert L. Bovey, President
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Managing Editor:
R. Wesley Miller
Director-Market Analysis:
Treva E. Klingbiel
Editor:
France Addington-Lee
Assistant Editor:
Kenten D. Lindberg
Editorial Assistant:
Alan L. Wolcott
Supply Analysis:
Thomas C. Pool
Demand Analysis:
John M. Vallance
Market Analysis:
David S. Schramm
Research Services:
Carolyn B. McCants
Subscription Services:
Lori A. Mattics
Washington Focus:
Linda L. Gunter

Published by:
NUEXCO
Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202
Telephone: (303) 899-4500
Telefax: (303) 899-4555
Telex: (303) 450202 (NUEXCO)

Other NUEXCO Publications:
Annual Review;
Nuclear Fuel Market Study;
International Directory of Nuclear Utilities (IDNU);
International Directory of Uranium Producers (IDUP)

TABLE OF CONTENTS

Market Review 1
- Market Values Summary
- August Market Review
- Current Market Data

Recent Developments 12
- Isotope Technologies Announces New Partners
- Washington Focus
- Industry Briefs

Essay 17
- **Electrical Energy Alternatives and Their Effect on the Environment** — An essay by J. Robert Wolcott, chairman of NUEXCO's International Advisory Committee, discusses many of the issues prevalent in today's energy industry. All energy alternatives have pros and cons; so in this environmentally-conscious era, what direction should the United States choose?

Raw Materials 26
- **The Crow Butte Project Nears Production**
The Crow Butte Mining Project received its permit to construct from the Nebraska Department of Environmental Control on April 24, 1990, making it Nebraska's first uranium production project. The permit opened the way for commercial development of what is likely to be one of the USA's lowest-cost producers.

Focus 29
- **Czechoslovakia's Nuclear Power and Fuel Programs**
Czechoslovakia has been one of Eastern Europe's most active uranium producers for more than 40 years and has an ambitious nuclear power program that extends into the 21st century. However, changing COMECON relationships, rapid internal political changes, capital constraints, and newly-expressed concerns about nuclear safety have left plans open to examination and alteration.

Nuclear Industry Calendar 40
Historical Market Data 41
Government Statistics 47

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To Our Readers

The CONCORD/NUEXCO organization is pleased to announce that Mr. **Berwyn Edwards** has joined the CONCORD Group effective September 1, 1990. Berwyn is the former Head of the British Civil Uranium Procurement Organization (BCUPO). BCUPO is the division of the Nuclear Fuel Cycle Department of Nuclear Electric (formerly CEGB) responsible for managing all of the uranium requirements for the UK nuclear program.

Berwyn holds a Mechanical Engineering degree from the University of Wales. He also led the team that acquired the Highland uranium mine in 1989 for Power Resources Inc. (PRI)—a wholly-owned subsidiary of Nuclear Electric. Berwyn will be a Vice-President of CONCORD Resources, Ltd., and Office Director of Operations of CONCORD's London Office. He will be active in NUEXCO's nuclear fuel activities as well as some of CONCORD's other businesses.

* * *

NUEXCO will host a hospitality suite at the US Council for Energy Awareness' International Uranium Seminar 1990 to be held September 16-19 in San Antonio, Texas. We look forward to seeing you there.

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MARKET REVIEW

MARKET VALUES SUMMARY

August 31, 1990

NUEXCO Market Values	This Report August 31, 1990	Last Report July 31, 1990	12 Months Ago August 31, 1989
EXCHANGE VALUE[1]	**$11.45**/lb equivalent U_3O_8	$11.70	$9.70
UF_6 VALUE[2]	**$32.25**/kg U as UF_6	$32.50	$29.75
LOAN RATE[3]	**3.5%**/annum	3.5%	3.5%
CONVERSION VALUE[4]	**$1.45**/lb U as UF_6	$1.45	$1.90
SWU VALUE[5] **(0.3 tails assay)**	**$50**/SWU	$50	$65
TRANSACTION VALUE[6]	**$10.80**/lb equivalent U_3O_8	$9.75	$9.80
Transactions	**27**	35	15
Months	**3**	3	3
Millions of Pounds	**5.5**	9.1	2.1

DEFINITIONS

[1] The **Exchange Value** is NUEXCO's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.

[2] The **UF_6 Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.

[3] The **Loan Rate** is NUEXCO's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.

[4] The **Conversion Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.

[5] The **SWU Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.

[6] The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:

a. Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;
b. At least ten transactions;
c. Transactions involving a sum total of at least 2 million pounds equivalent U_3O_8.

DERIVATIONS AND COMMENTS

- All **Market Values** are expressed in terms of US$.
- All **Market Values** are based on:
  - Data from recently completed transactions.
  - Data from pending transactions.
  - Firm bids to buy or borrow, and firm offers to sell or lend.
  - Prices purchasers or rates borrowers have expressed a willingness to pay, but for which NUEXCO is not aware of firm bids to buy or borrow and prices sellers or rates lenders have expressed a willingness to accept, but for which NUEXCO is not aware of firm offers to sell or lend.
- Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these **Market Values**.
- In the determination of prices, NUEXCO does not consider charges for transportation other than that customarily provided by suppliers.
- The prices of services or materials delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.
- For the **SWU Value**, NUEXCO converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U^{235} and a product assay of 3.0 weight-percent U^{235}, assuming feed costs corresponding to the NUEXCO **Exchange Value** and **Conversion Value** determined as of the same date.
- In calculating the **Transaction Value**, NUEXCO does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future **Exchange Values** or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it can not currently be determined.
- The sample time for the **Transaction Value** is extended as necessary to satisfy the minima for the number of transactions and quantity of material. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

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AUGUST MARKET REVIEW

(as of August 31, 1990)

OVERVIEW

August, often a slow month in the nuclear fuel market, was particularly slow this year. Only three natural uranium sales are reported, and near-term market volume fell short of one million pounds equivalent U_3O_8 for the first time since January. Moreover, no enriched or long-term uranium sales are reported.

The Exchange Value and the UF_6 Value each declined $0.25, to $11.45 per pound U_3O_8 and $32.25 per KgU as UF_6 respectively, the first such decline since February of this year. The modest decline of the Exchange and UF_6 Values reflects the near-term softening of the uranium market. The Loan Rate, Conversion Value, and SWU Value all remain unchanged from their July 31 levels. Only two conversion sales, one loan, and one SWU sale are reported.

The August market volume of 800 thousand pounds equivalent U_3O_8 is less than one-fourth the average monthly volume over the previous 12 months. It is also the lowest monthly volume since the August 1989 level of 260 thousand pounds equivalent U_3O_8. Year-to-date, near-term uranium sales volume, including a very large sale that was made earlier in the year, but which is only now being officially reported, now stands at nearly 33 million pounds equivalent U_3O_8 (**Table 1**). Thus, in only eight months, this year's spot and near-term uranium sales volume has set a new annual record.

Table 1
NEAR-TERM URANIUM SALES SUMMARY

	August 1990		Year-to-Date	
	No. of Sales	Volume[1]	No. of Sales	Volume[1]
Concentrates Natural UF_6	3	0.8	47 27	19.1 9.5
EUP	0	0.0	9	4.2
Total	3	0.8	83	32.8

[1] Million Pounds Equivalent U_3O_8

NATURAL URANIUM AND CONVERSION

The August 31 **Exchange Value** declined slightly, to **$11.45** per pound U_3O_8, down $0.25 from the July 31 level of $11.70 per pound U_3O_8. This decline is the first drop in the Exchange Value since February 28, 1990. Although the record annual sales volume was surpassed in August, the level of market activity in August was low by any measure, particularly when compared to the hectic pace of the first half of the year. Market volume over the past twelve months has averaged 3.8 million pounds equivalent U_3O_8 per month, yet August's three uranium sales totalled only 800 thousand pounds equivalent U_3O_8. Two of these sales involved concentrates, the other involved natural UF_6. Buyers have largely completed their purchasing activity, so demand has declined significantly. And as higher prices have brought more supply into the market, the upward pressure on the Exchange Value has subsided and the market has softened somewhat.

One additional spot sale is reported this month, although it took place earlier in the year. An Australian producer sold its entire stockpile of inventory–in the form of concentrates–to a European intermediary. This is only being reported now that much of the previously proprietary information has been made public. This sale is not included in August's market totals because it occurred earlier in the year, but the year-to-date information in Table 1 has been updated to reflect this transaction.

No long-term uranium sales are reported for August.

* * *

The **UF_6 Value** decreased $0.25, to **$32.25** per KgU as UF_6, marking the first time in five months that the UF_6 Value has declined. As in the concentrates market, lack of demand and ample supply characterize the UF_6 market. In the only UF_6 sale reported, a US utility purchased a moderate quantity of UF_6 from an intermediary at a price near the August 31 UF_6 Value.

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Table 2
NEAR-TERM SUPPLY/DEMAND SUMMARY

	Active Supply [1]	Active Demand [1]
• Natural Uranium [2] (thousand lbs equivalent U_3O_8)	5,400	830
• Supply/Demand Ratio:	6.5	
• Loan (thousand lbs equivalent U_3O_8)	7,345	0
• Conversion (thousand lbs U as UF_6)	0	400
• SWU (thousand SWUs)	435	75

[1] Supply and demand tables in the current market data section of this Report provide details for each category.
[2] Includes concentrates and hexafluoride.

The **Transaction Value** increased for the third consecutive month, to **$10.80** per pound U_3O_8, based on 27 transactions over three months involving 5.5 million pounds equivalent U_3O_8. This $1.05 increase is the largest absolute increase in the Transaction Value since July 1983. The increase came about largely because the lower-priced transactions from May no longer fall within the three-month time frame used when calculating the Transaction Value. The high volume of May's lower-priced transactions had heavily influenced previous Transaction Value calculations, reducing the increases of June 30 and July 31. The large spot sale of concentrates from earlier in the year is not included in the August 31 Transaction Value calculation because it falls outside the qualifying time period (June through August).

* * *

Active uranium supply decreased slightly to **5.4** million pounds equivalent U_3O_8, but it still remains well above **active uranium demand** of **830** thousand pounds equivalent U_3O_8 (**Table 2**). The resultant **supply/demand ratio** is **6.5**. The abundance of uranium supply in the form of both concentrates and UF_6, and the significant easing of demand, acted together to weaken the market somewhat, so market prices have subsided from their recent peaks. Further adjustment may occur as market participants recognize and react to this supply abundance.

* * *

The **Loan Rate** remains at **3.5** percent per annum. Only one loan is reported for August; a US utility lent over one million pounds equivalent U_3O_8 for return in 1991, at a rate near the August 31 Loan Rate. Loan supply remains plentiful, contributing additional material to the prevailing abundance of supply.

* * *

The **Conversion Value** is unchanged at **$1.45** per pound U as UF_6. The two August conversion sales totalled over one million pounds U as UF_6. One sale involved a US utility buyer; in the other, a European utility bought from a European intermediary. Both sales transpired at levels near the August 31 Conversion Value. While conversion supply is shown as zero in Table 2, ample UF_6 remains available for deconversion.

After five successive months of UF_6 selling at more than a dollar discount from the sum of the values of its components—concentrates and conversion—that discount has now fallen to $0.86 per KgU as UF_6, the smallest since February. Although UF_6 remains plentiful, the large oversupply typical of the first half of the year has abated. Without a large oversupply of UF_6, and with the now ample supplies of concentrates, the downward pressure on the Conversion Value has dissipated. However, the balance between UF_6 and concentrates has not shifted far enough to create any significant upward pressure on the Conversion Value in the near-term.

* * *

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ENRICHMENT SERVICES AND ENRICHED URANIUM PRODUCT

The August 31 **SWU Value** is also unchanged, remaining at **$50** per SWU for the seventh consecutive month. Only one SWU sale is reported. This sale of a moderate quantity of SWU, from a European intermediary to a US utility, calls for delivery in 1991. SWU supply remains plentiful, especially SWU contained in EUP (enriched uranium product).

Recently, some buyers have entered the enrichment services market with special timing needs. These buyers needed SWU, but were unable to give sellers the standard 180-day lead time. As is often the case, such requests can be difficult to fill, and a premium SWU price usually is necessary to meet such a need. However, competition in the secondary enrichment market has created enough opportunities such that shorter lead-times can occasionally be accommodated. ■

Table 3
ENRICHMENT PRICES
(August 31, 1990)

Prices	This Month Report 265	Last Month Report 264	12 Months Ago Report 253
NUEXCO SWU Value ($US per SWU)	50	50	65
US DOE SWU prices: ($US per SWU)			
USEC	117.85[1]	117.85[1]	117.00[2]
AFC	153.00[3]	153.00[3]	153.00[3]
Requirements	157.00[3]	157.00[3]	157.00[3]
Incentive Price (IP1)	90.00[4]	90.00[4]	90.00[4]
Calculated worth of enriched UF_6[5]: ($US per KgU as UF_6)			
2.0 w/o U_{235}	222	225	232
2.5 w/o U_{235}	304	308	323
3.0 w/o U_{235}	389	393	417
3.5 w/o U_{235}	475	480	512
4.0 w/o U_{235}	562	568	609
4.5 w/o U_{235}	650	657	707

[1] Effective 10/1/89 to 9/30/90.
[2] Effective 10/1/87 to 9/30/89.
[3] Effective since 10/1/84.
[4] Effective 10/1/86 to 9/30/90, for up to 30% of annual requirements.
[5] Calculated using the NUEXCO Exchange Value, Conversion Value, SWU Value and 0.30 w/o tails assay.

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RECENT TRANSACTIONS

Uranium Sales[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds equivalent U_3O_8)	Price Within Percentage Range[2] of Current Exchange or UF_6 Value	Buyer	Seller	Remarks
4925	1990	101-300	103-110	Intermediary	Producer	
4928	1990-1991	301-600	**R**	Utility	Producer	
4930	1990	6,001-10,000	**R**	Intermediary	Producer	Occured earlier in 1990
4931	1991	50-100	98-102	Utility	Intermediary	UF_6

Natural Uranium Loans[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds equivalent U_3O_8)	Price Within Percentage Range[2] of Current Loan Rate	Borrower	Lender	Remarks
4938	1990	1,001-3,000	98-102	**R**	Utility	

Conversion Sales[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds of U equivalent)	Price Within Percentage Range[2] of Current Conversion Value	Buyer	Seller	Remarks
4927	1991	301-600	98-102	Utility	**R**	
4937	1991	601-1,000	90-97	Utility	Intermediary	

Enrichment Sales[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity[3] (thousand SWU)	Price Within Percentage Range[2] of Current SWU Value[4]	Buyer	Seller	Remarks
4933	1991	50-100	103-110	Utility	Intermediary	

R means that NUEXCO either does not know, or that NUEXCO has restricted that information to protect client or source confidentiality.

[1] Transactions listed are not limited to those in which NUEXCO was involved, but also include others of which NUEXCO is aware. NUEXCO may delay reporting some transactions in order to protect proprietary information.

[2] The ranges *Below 90, 90-97, 98-102, 102-110, Above 110*, represent percentages (rounded to whole numbers) of the appropriate current Market Value. The endpoints of each range are included within that range.

[3] If tails assay is unknown or unspecified, NUEXCO's calculation of SWU quantity assumes 0.30 w/o tails assay.

[4] Prices are usually normalized to 0.30 w/o tails assay. When prices and SWU values are expressed as discounts from a reference price (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage price range is based on the discounted prices, not on the reference price.

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SUPPLY AND DEMAND

Uranium Supply

NUEXCO Project Number	Quantity (Thousand Pounds equivalent U_3O_8) Spot or Near-term[1]	Intermediate or Long-term[2]	Delivery Period	Remarks
Available for Sale				
ACTIVE				
89-1001*	1,305	--	1991	UF_6
89-1180	350	--	1990	
90-1078A	2,175	2,175 per year	1991-1993	UF_{6e}
90-7001*	1,000	1,000 per year	1991-1995	
90-1183	70	--	1990-1991	
90-1200*	500	--	1990	
Total	**5,400**			
INACTIVE	**500**			
Available for Loan				
ACTIVE				
88-1182	4,000	--	--	U_3O_8/UF_6
90-1016	300	--	--	U_3O_8
90-1033	1,270	--	--	UF_6
90-1108	1,000	--	--	U_3O_8
90-1110	250	--	--	U_3O_8
90-1180	525	--	--	U_3O_8
Total	**7,345**			
INACTIVE	**1,390**			

* New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes material deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Active Projects reclassified as Inactive since last month: 90-1115.
Active Projects removed since last month: 90-1175.

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SUPPLY AND DEMAND

Uranium Demand

NUEXCO Project Number	Quantity (Thousand Pounds equivalent U_3O_8) Spot or Near-term [1]	Intermediate or Long-term [2]	Delivery Period	Remarks
Inquiries to Purchase:				
ACTIVE				
90-1100A	45	--	1991	UF_6e
90-1177A	260	--	1991	UF_6e
90-1182	25	--	1991	
90-1199*	500	--	1990	U_3O_8/UF_6
90-1098	--	250 per year	1992-1994	
90-1155	--	325 per year	1991-1995	
90-1170	--	290	1992-1996	
Total	**830**			
INACTIVE	**2,080**			
Inquiries to Borrow	*No inquiries to borrow are reported*			

* New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes material deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Active Projects removed since last month: 90-1113, 90-1171.

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MARKET REVIEW

SUPPLY AND DEMAND

Conversion Supply And Demand

NUEXCO Project Number	Quantity (Thousand Pounds U as UF_6) Within 3 Years[1]	 Beyond 3 Years[1]	Remarks
Available for Sale	*No offers to sell are reported*		
Inquiries to Purchase			
ACTIVE			
90-1184	**400**	--	
Total	**400**		
INACTIVE	*None reported*		

* New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: *none*.

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SUPPLY AND DEMAND

SWU Supply And Demand

NUEXCO Project Number	Quantity (Thousand SWUs)		Delivery Period	Remarks
	Spot or Near-term[1]	Intermediate or Long-term[2]		
Available for Sale				
ACTIVE				
90-1078B	435	435 per year	1991-1993	UF_6e
90-7000	--	1,000	1991 on	
Total	**435**			
INACTIVE	*None reported*			
Inquiries to Purchase				
ACTIVE				
90-1100B	15	--	1991	UF_6e
90-1177B	60	--	1991	UF_6e
88-1061	--	500	1991-1995	
90-1076	--	350 per year	1992-1998	
90-1094	--	500	1992-2000	
90-1144	--	60 per year	1992-2001	
90-1181	--	600	1996-2003	UF_6e
90-1196*	--	60 per year	1995 on	
Total	**75**			
INACTIVE	**1,645**			

* New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes SWU deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Projects removed since last month: *none*.

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MARKET REVIEW

MARKET VALUES EXPRESSED IN SELECTED CURRENCIES

Exchange Value[1]

Country (currency)	per lb equivalent U3O8 as Concentrates This Month (Aug. 31, 1990)	Last Month (July 31, 1990)	12 Months Ago (Aug. 31, 1989)	per kg U as Concentrates This Month (Aug. 31, 1990)	Last Month (July 31, 1990)	12 Months Ago (Aug. 31, 1989)
Australia (dollar)	13.98	14.78	12.67	36.35	38.42	32.93
Belgium (franc)	368.29	386.27	396.08	957.46	1,004	1,030
Canada (dollar)	13.13	13.48	11.42	34.14	35.06	29.70
EEC (ecu)	8.68	9.11	9.05	22.56	23.68	23.52
Finland (markka)	42.22	44.06	42.71	109.77	114.54	111.04
France (franc)	60.12	62.83	63.82	156.29	163.34	165.91
Italy (lira)	13,294	13,747	13,593	34,561	35,739	35,339
Japan (yen)	1,652	1,732	1,399	4,294	4,502	3,638
Netherlands (guilder)	20.21	21.18	21.36	52.54	55.05	55.52
So. Africa (comm. rand)	29.32	30.41	26.64	76.23	79.07	69.26
Spain (peseta)	1,118	1,154	1,185	2,907	3,001	3,082
Sweden (krona)	65.96	68.50	64.03	171.47	178.09	166.45
Switzerland (franc)	14.83	15.91	16.33	38.56	41.35	42.45
UK (pound)	5.97	6.33	6.15	15.52	16.46	15.99
US (dollar)	11.45	11.70	9.70	29.77	30.425	25.22
West Germany (mark)	17.94	19.46	18.94	46.63	50.59	49.23

Transaction Value[1]

Country (currency)	per lb equivalent U3O8 as Concentrates This Month (Aug. 31, 1990)	Last Month (July 31, 1990)	12 Months Ago (Aug. 31, 1989)	per kg U as Concentrates This Month (Aug. 31, 1990)	Last Month (July 31, 1990)	12 Months Ago (Aug. 31, 1989)
Australia (dollar)	13.19	12.32	12.80	34.28	32.02	33.27
Belgium (franc)	347.38	321.89	400.16	903.11	836.84	1,040
Canada (dollar)	12.39	11.24	11.54	32.21	29.21	30.00
EEC (ecu)	8.18	7.59	9.14	21.28	19.73	23.76
Finland (markka)	39.82	36.71	43.15	103.53	95.45	112.19
France (franc)	56.70	52.36	64.47	147.42	136.12	167.62
Italy (lira)	12,539	11,456	13,733	32,599	29,782	35,703
Japan (yen)	1,558	1,443	1,414	4,050	3,751	3,675
Netherlands (guilder)	19.06	17.65	21.58	49.55	45.88	56.09
So. Africa (comm. rand)	27.66	25.34	26.92	71.90	65.89	69.97
Spain (peseta)	1,055	961.82	1,198	2,742	2,501	3,114
Sweden (krona)	62.21	57.08	64.69	161.74	148.41	168.17
Switzerland (franc)	13.99	13.25	16.50	36.37	34.46	42.89
UK (pound)	5.63	5.28	6.21	14.64	13.72	16.16
US (dollar)	10.80	9.75	9.80	28.08	25.35	25.48
West Germany (mark)	16.92	16.21	19.13p	43.98	42.16	49.74

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[1] Calculated using currency exchange rates published in *The Wall Street Journal* on the last working day of the month.

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MARKET VALUES EXPRESSED IN SELECTED CURRENCIES

CONVERSION VALUE[1]

Country (currency)	per lb U as UF_6 This Month (Aug. 31, 1990)	Last Month (July 31, 1990)	12 Months Ago (Aug. 31, 1989)	per kg U as UF_6 This Month (Aug. 31, 1990)	Last Month (July 31, 1990)	12 Months Ago (Aug. 31, 1989)
Australia (dollar)	1.77	1.83	2.48	3.90	4.04	5.47
Belgium (franc)	46.64	47.87	77.58	102.82	105.54	171.04
Canada (dollar)	1.66	1.67	2.24	3.67	3.68	4.93
EEC (ecu)	1.10	1.13	1.77	2.42	2.49	3.91
Finland (markka)	5.35	5.46	8.37	11.79	12.04	18.44
France (franc)	7.61	7.79	12.50	16.78	17.17	27.56
Italy (lira)	1,684	1,704	2,663	3,711	3,756	5,870
Japan (yen)	209.17	214.59	274.09	461.15	473.09	604.27
Netherlands (guilder)	2.56	2.62	4.18	5.64	5.79	9.22
So. Africa (comm. rand)	3.71	3.77	5.22	8.19	8.31	11.50
Spain (peseta)	141.59	143.04	232.19	312.15	315.35	511.89
Sweden (krona)	8.35	8.49	12.54	18.41	18.72	27.65
Switzerland (franc)	1.88	1.97	3.20	4.14	4.35	7.05
UK (pound)	0.76	0.78	1.20	1.67	1.73	2.66
US (dollar)	1.45	1.45	1.90	3.20	3.20	4.19
West Germany (mark)	2.27	2.41	3.71	5.01	5.32	8.18

SWU VALUE AND UF_6 VALUE[1]

Country (currency)	SWU Value at 0.30% Tails Assay This Month (Aug. 31, 1990)	Last Month (July 31, 1990)	12 Months Ago (Aug. 31, 1989)	UF_6 Value per kg U as UF_6 This Month (Aug. 31, 1990)	Last Month (July 31, 1990)	12 Months Ago (Aug. 31, 1989)
Australia (dollar)	61.05	63.16	84.89	39.38	41.05	38.85
Belgium (franc)	1,608	1,651	2,654	1,037	1,073	1,215
Canada (dollar)	57.35	57.62	76.54	36.99	37.46	35.03
EEC (ecu)	37.89	38.92	60.62	24.44	25.30	27.74
Finland (markka)	184.37	188.27	286.22	118.92	122.38	130.99
France (franc)	262.52	268.50	427.63	169.33	174.52	195.72
Italy (lira)	58,052	58,748	91,087	37,443	38,186	41,690
Japan (yen)	7,213	7,400	9,377	4,652	4,810	4,292
Netherlands (guilder)	88.25	90.50	143.11	56.92	58.82	65.49
So. Africa (comm. rand)	128.04	129.97	178.52	82.59	84.48	81.70
Spain (peseta)	4,882	4,932	7,943	3,149	3,206	3,636
Sweden (krona)	288.02	292.74	429.04	185.77	190.28	196.36
Switzerland (franc)	64.78	67.97	109.43	41.78	44.18	50.08
UK (pound)	26.07	27.06	41.22	16.81	17.59	18.86
US (dollar)	50.00	50.00	65.00	32.25	32.50	29.75
West Germany (mark)	78.32	83.15	126.90	50.52	54.05	58.08

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[1] Calculated using currency exchange rates published in *The Wall Street Journal* on the last working day of the month.

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RECENT DEVELOPMENTS

USA

Isotope Technologies Announces New Partners

On August 20, Isotope Technologies, Inc. (ITI) announced the formation of a joint venture with two Canadian partners—Cameco, the world's largest uranium producer, and Agra Industries, Ltd., an architectural/engineering firm—both of which are based in Saskatoon, Saskatchewan. The new venture, called CRISLA Technologies, is also based in Saskatoon. It utilizes ITI-developed CRISLA technology (chemical reaction by isotope selective laser activation) to chemically enrich uranium. CRISLA Technologies will conduct its research at Cameco's facilities with engineering support provided by Agra; marketing efforts will remain based in California at ITI headquarters.

This announcement marks the movement of CRISLA R&D into the technology demonstration phase. The new company hopes to build a commercial-scale 1000-SWU module by 1992. After the process has been demonstrated and verified, the company plans to build a pilot plant, adding modules to reach an annual production capacity of 100,000 SWU. The partners' long-range plans call for a 250–500 thousand SWU per year capacity. John Longenecker, President of ITI, projects development costs of $50 million for the first SWU module through initial production. Cameco and Agra will match the investment ITI has made to date.

One benefit of Cameco's participation is that this technology is ideally suited to the back end of a conversion plant. By locating an enrichment plant at a conversion plant, it eliminates the need to transport hazardous UF_6, and also allows the fluorine used in the enrichment process to be recycled into the conversion process. Another advantage is that by locating the enrichment facility at an existing, licensed site in Canada, CRISLA Technologies may succeed in demonstrating the technology sooner.

John Longenecker and William Pearson, Vice President for Agra's engineering group, will serve as Directors of CRISLA Technologies, and Bernard Michel, Cameco's Executive Vice President, will be Chairman. Dr. Dennis G. Garratt of Cameco has been appointed Project Manager. ■

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WASHINGTON FOCUS

Congress was in recess during August, but some developments occurred in other branches of the US government. The President's Commission on Catastrophic Nuclear Accidents issued a report with recommendations to Congress regarding the Price-Anderson Act. The Congressional Budget Office released its preliminary estimate of the FY90 budget deficit, and if Congress does not reach agreement on a budget, cuts required by the Gramm-Rudmann Act could cause major problems for DOE. DOE has also asked Congress to reconsider, after turning down a request in July, reprogramming $20 million from the uranium enrichment account to other accounts. President Bush signed the Customs and Trade Act of 1990, which may reduce the cost of importing nuclear fuel.

Presidential Commission Issues Report

The President's Commission on Catastrophic Nuclear Accidents issued a report that includes recommendations to Congress for several changes in the compensation procedures for claims relating to accidents covered by the Price-Anderson Act. The Price-Anderson Act provides tertiary coverage to the public in case of a major nuclear accident. It outlines provisions for compensation to victims of a nuclear accident beyond the coverage provided by the individual utility (primary) and by the entire industry (secondary). For example, the Commission recommends that claims should be handled by a judicial system, rather than an administrative system. A second recommendation is a no-fault claim system, whereby anyone developing cancer after exposure to a nuclear accident would be compensated, regardless of whether proof exists that the cancer resulted from that exposure.

FY90 Budget Deficit Troublesome for DOE

The Congressional Budget Office has released its initial estimate of the US government's FY90 deficit. This deficit estimate could cause DOE to face a 32.4 percent across-the-board reduction in spending authority under the Gramm-Rudman Act's authority to sequester accounts. If the sequester takes place, the uranium enrichment account would be cut by approximately $400 million. These cuts would reduce government revenue, lead to staff reductions, and could postpone the AVLIS R&D program. According to DOE's enrichment program budget officer, the potential damage from such a sequester makes it an "unimaginable cut." Upon returning in September, Congress is likely to vote to ignore, or somehow weaken, the requirements of the Gramm-Rudman Act. With Congressional elections upcoming in November, Congress will be reluctant to make tough decisions about reducing the budget deficit.

DOE Asks Congress to Reconsider Reprogramming Request

DOE requested that Congress reconsider its decision not to allow a reprogrammming of $20 million from the uranium enrichment account to accounts for advanced reactor research, waste disposal research, and the restart of the Savannah River defense facility. (Congress denied the original request last month.) DOE Comptroller Elizabeth Smedley wrote to reassure Congress that the uranium enrichment account has adequate funds, and would not suffer from the requested reprogramming. "The department currently has over $700 million in balances which would be available to the

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new corporation." This $700 million has never been itemized in the uranium enrichment account before, but has existed by Congressional concurrence that funds for the new government corporation need to be set aside. However, compared to the expected operating costs, $700 million is only a small portion of what will be required. According to a Congressional staffer, the proposed corporation will need $100-$150 million per month for operating expenses, in addition to the demand charge payments that must be made to TVA. Congress may act on the reprogramming request when it returns in September.

President Signs Customs and Trade Act

On August 20, President Bush signed the Customs and Trade Act of 1990, which will bring customs-user fees into compliance with the General Agreement on Tariffs and Trade (GATT). Effective October 1, the new fee schedule imposes a ceiling of $400 for each entry, with a minimum fee of $21. As required by GATT, fees charged will approximate the cost of services rendered. This Act will reduce the cost of importing nuclear fuel, but the savings may be offset by a potential increase in the harbor maintenance fee.

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INDUSTRY BRIEFS

Bechtel,Westinghouse And Consumers Form Joint Venture To Operate Palisades

After nearly three years of negotiations, Consumers Power Co. has agreed to sell a 55-percent interest in its Palisades nuclear power plant to Westinghouse Electric Co. and Bechtel Power Corp. Westinghouse will invest $20 million for a 22-percent interest, and Bechtel will invest $30 million for a 33-percent interest. The three companies will form a partnership, Palisades Generating Co., to own and operate the plant as an independent power producer (IPP). The deal should close early in 1991.

Westinghouse will acquire only 4.9 percent of the voting rights, thereby avoiding the five-percent level that would restrict its involvement in similar arrangements in other states. Consumers Power will manage the 760-MWe South Haven, Michigan plant and purchase its ouptut.

The Michigan Public Service Commission is contesting the planned sale of the plant to the IPP partnership, because the sale would eliminate the commission's jurisdiction over consumer rates. The Federal Energy Regulatory Commission has jurisdiction over consumer rates for IPP-generated electricity, and has commonly been more generous to utilities than have state commissions.

British Government To Sell PowerGen In Public Offering

Continuing the move toward privatization of Britain's electrical power generation, the British government has terminated talks with Hanson PLC about the sale of state-owned PowerGen. PowerGen is one of Britain's two non-nuclear electricity generating companies. On August 23, Energy Secretary John Wakeham indicated that the government had decided to return to its original plan to sell PowerGen to the public, rather than to Hanson PLC, a private firm, because the public sale could raise in excess of £1.1 billion.

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NPT Conference Opens In Geneva

The fourth review conference of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) opened in Geneva, Switzerland on August 20, and is scheduled to conclude on September 14. This conference is important because it is the last meeting before the 1995 conference, which must decide whether to extend the NPT (and if so, for how long). Two nuclear weapons states, France and China, have not signed the NPT, but have asked for the first time to attend the review conference as observers.

Soviets Buy US Computers For Nuclear Safety

The US government and the 17-nation Coordinating Committee for Multilateral Export Controls have approved the Soviet Union's $32-million purchase of six Control Data Corp. computers, for use in nuclear power plant safety research and development. The computers are six times more powerful than any previously sold to the Soviet Union. Although stringent safeguards to prevent military use are conditions of the sale, it is still an important indicator of improving US-Soviet relations, and a major step in assisting the Soviet Union in improving its nuclear power plant safety. The first shipments are scheduled for September 1990.

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Cameco Completes Sale Of Interest In Rabbit Lake

On July 25 in Bonn, West Germany, Cameco completed its sale to Uranerz Exploration and Mining, Ltd. (a Canadian subsidiary of Bonn-based Uranerzbergbau GmbH) of a one-third interest in Cameco's Rabbit Lake Mill, and Collins Bay and Eagle South deposits. The C$160 million sale followed an agreement reached between the two companies on April 2, 1990 (April Monthly Report #260, p. 20). Uranerz already shared interests with Cameco in the Key Lake facilities and Eagle North deposits.

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Ebasco And CEGA Each Win Defense Reactor Contract

DOE announced it will award two design contracts worth $1.5 billion each; one to Ebasco Services and one to CEGA, Inc. The contracts involve replacing the reactors used to generate tritium at the Savannah River facility. Westinghouse did not win a contract—its Eagle 2000 HWR design met all criteria, but the design was unproven and would have required a complex refueling procedure. The Ebasco and CEGA designs use a greater number of proven technologies, and DOE concluded those designs would result in a more reliable projections of operating dates. DOE estimates the cost to complete the two reactors is $7.7 billion.

CEGA, a joint company of ABB-Combustion Engineering and General Atomics, designed a Modular Helium Reactor (MHR) that shares over three-fourths of its components with GA's civilian MHR design. Ebasco, a subsidiary of Enserch Corp., submitted an HWR design. Improved US-Soviet relations have Congress calling into question many defense expenditures, so uncertainty exists as to whether Congress will approve the design engineering work for two separate designs, or if it will approve the construction of any defense reactors.

East German Utility Takeover Settled

Several companies and government officials have reached a preliminary agreement on the future of East Germany's electrical generation industry. The initial plan, proposed by West Germany's three largest utilities, Bayenwerk AG, Preussenelektra AG, and RWE AG (August Monthly Report #264, p. 20), was turned down in August by the East German Parliament and anti-cartel authorities in both East and West Germany. Following this denial, the three utilities initiated new discussions with East German authorities. The new agreement will permit other interested parties to participate. Details are still being negotiated. When finalized, the agreement will clear up one more matter from the many issues that need to be resolved before the October 3, 1990 unification date that the two Germanies announced this month.

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Rio Algom Shuts Down Quirke And Panel Early

Rio Algom announced in late July that production at its Quirke and Panel uranium mines would cease at the end of August. An earlier announcement (February Monthly Report #258, p. 18) stated production was to cease in early 1991. Rio Algom has applied to the Atomic Energy Control Board for decommissioning licenses for the two mines.

General Atomics Buys Beverley Mine

General Atomics (GA) has concluded an agreement to acquire the Beverley uranium property from TMOC Resources, a subsidiary of Australia Gas Light Company, pending final approval by Australian government authorities. TMOC, which had owned 50% of the deposit, acquired Western Nuclear's 50% interest earlier this year, giving TMOC 100% ownership.

GA's long-term objective is to develop the property, subject to market conditions and Australian government approval. The Beverley deposit is located north of Adelaide, South Australia; its estimated reserves total approximately 30 million pounds equivalent U_3O_8, at an average grade of 0.27% U_3O_8. This acquisition of the Beverley deposit is GA's first step in a strategy of expanding its front-end fuel cycle activities beyond its Sequoyah Fuels Corp. conversion business.

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ESSAY

ELECTRICAL ENERGY ALTERNATIVES AND THEIR EFFECT ON THE ENVIRONMENT

This essay by J. Robert Wolcott, chairman of NUEXCO's International Advisory Committee, discusses many of the issues prevalent in today's electrical energy industry. All energy alternatives have pros and cons; so in this environmentally conscious era, what direction should the United States choose?

The United States has alternated its favored electrical energy sources several times over the past fifty years. It may soon change course again. Fifty years ago, the favored source was hydroelectric power. Electricity demand at the time was relatively small in comparison to today. Many rivers provided excellent, economical sites. In the 1950s, rapid growth in demand shifted interest to gas and oil because they were relatively clean, cheap, and easily transportable.

A growing dependency on foreign oil led to the oil embargo and the rapid increase of prices in the 1970s. Use of oil was then discouraged by cost and federal regulation. Natural gas prices rose with oil prices, and federal regulations multiplied. Coal and uranium emerged as the favored fuels. However, nuclear power then came into disfavor in the late 1970s and throughout the 1980s. Emphasis on coal increased. The need for short construction schedules and reduced atmospheric emissions has since returned the emphasis to natural gas. Now pollution concerns are calling all fossil fuels into question.

> ***Electricity is the heart of the American industrial system and far too important to be tinkered with based on theory rather than experience.***

Hydroelectric sites are unavailable. Oil supplies are limited and foreign sourced. Coal is recognized as a major source of pollution. Natural gas is costly and limited. Renewable energy sources are incapable of meeting needs. And nuclear power safety and waste disposal issues still hinder its acceptance. So, where does the United States go from here?

The Swedish Example

How does the Swedish example relate to the United States? First, Sweden is a small country where the energy picture comes more clearly into focus than in the much larger United States. Moreover, Sweden's environmental and political course is much like that of the USA. Sweden's evolution may help us see more clearly what problems lie ahead for the USA. Finally, Sweden's solutions may guide the USA. Half of Sweden's electric power is hydroelectric and half is nuclear. In March 1980, shortly after the Three Mile Island (TMI) accident, the public voted to phase out nuclear power. The completion date was set for the year 2010. Subsequently, Sweden added constraints on non-nuclear energy. A carbon dioxide emission increase was forbidden for environmental reasons. Further development of hydroelectric was prohibited to avoid environmental damage to rivers. Oil and gas were viewed with disfavor because both had to be imported. Solar, windmills, conservation, and other non-conventional sources were encouraged, but proved mostly impractical. Ample electrical power was available due to surpluses, so these decisions had no immediate impact. However, the surplus could not satisfy growing needs indefinitely. A moment of truth has arrived. Swedish utilities pointed out that they cannot wait until 2010 to act. A phased shutdown with a parallel building of replacements is required. The utilities proposed the shutdown of two of Sweden's twelve nuclear plants as a start; the first in 1995 and the second in 1996, and an immediate start of construction for replacements.

Now real issues had to be addressed. Should nuclear really be shut down? Should it be replaced? What technology was superior? Who should pay? Can Swedish industry survive, much less remain competitive, without ample electricity?

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The Minister of Energy and Environment argued that Sweden need not worry. Effective conservation would allow a 50-percent reduction in consumption even while GNP grew 50 percent. Labor and industry, among others, did not accept that argument. Sweden's energy intensive industries are expected to grow. Sweden is expected to remain among the top few nations in per capita electrical consumption. Sweden's industrial growth is already lagging that of all of Western Europe. The public is taking another look. Recent opinion polls indicate the public favors hydro first, nuclear second, gas third, oil fourth, and coal fifth. The Minister of Energy has been replaced.

So Sweden is without a national energy policy and is in the grips of an "energy gridlock." A new plan is to be prepared for consideration by Parliament in early 1991. What will that plan entail? I believe it will evolve over time such that it:

- will not allow nuclear shutdowns;
- will ease carbon dioxide emission limits;
- will continue to prohibit large scale hydro development;
- will restate hopes for conservation;
- will express renewed interest in new, safety-intensive nuclear energy concepts.

The United States Parallel

One can, of course, see conditions in Sweden that are similar to those evolving in the USA, where many contradictions become publicized. Some have no scientific or economic foundation and some are realistic. The following list illustrates the diversity of opinions that one reads, hears, and sees via the media.

- Acid rain, ozone depletion, and global warming are leading to an uninhabitable earth.
- Global warming has already begun. By the end of the next century the world's average temperature will have increased 3 to 8 degrees; the sea level will have risen several feet; coasts will have flooded; weather patterns will have changed. A crash corrective program is essential.
- Carbon dioxide emissions must be reduced 20 percent by the year 2000 and much more by the middle of the century.
- Deforestation is decreasing carbon dioxide absorption capacity. More trees must be planted. South American nations must stop clearing forests.
- The "population bomb" is about to explode.
- Third-world countries must industrialize and more use of fossil fuels is necessary. Industrialized countries must reduce energy use to compensate.
- Electric energy growth and economic growth go hand in hand. All nations—developed and undeveloped— need more electricity.
- The electrical automobile is a necessity.
- The present generation is morally obligated to preserve fossil fuels for future generations.
- Imported oil is jeopardizing national security.
- Nuclear power safety is inadequate, waste problems have not been solved, and public opinion will not permit new construction.
- We need not worry. Conservation will allow the US economy to grow even though consumption is reduced to 25 to 40 percent of current levels.
- With more development support, windpower, wood, biomass, solar, and other renewables will be the way of the future.
- A national energy policy is the solution.
- An "environmental democracy" (whatever that is), is the solution.

The list is far from complete, but that sampling does illustrate the challenge of developing a working consensus.

United States Supply and Demand Situation

Now, let's turn to supply and demand considerations where facts, rather than rhetoric, take precedence. Since the oil embargo, total energy use has remained essentially flat. While non-electric energy use has declined six percent (largely because of more efficient automobiles), use of electricity has risen 50 percent. Demand growth for the past several years has been about four percent per year, while new capacity additions have been only about one percent per year. The utility industry has met demand by capitalizing on surpluses available from excesses created earlier from construction starts which had been planned when the anticipated growth rate was 7 percent. Improved load balancing and transmission systems aided further. Conservation reduced demand approximately three percent, almost the equivalent of one year's growth. Supply problems are now becoming more apparent as the national reserve margin is shrinking. While modest surpluses of capacity continue in the Southwest and Northwest, the Northeast and Atlantic regions are on the edge of brownouts.

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Most forecasters project demand to increase at a rate of 2 to 3 percent per year for the forthcoming decade. Even at this level, which is lower than the past decade, additional capacity equivalent to approximately 200 new plants will be needed by the year 2000. How will that be accommodated? Because of restraints on coal, oil, and nuclear, the utility industry is resorting to natural-gas-fired turbine plants as an expedient. Gas has high total production costs, but fills a need because such units can be built quickly with minimum controversy. Formerly, gas turbines were constructed almost wholly to meet peak load demands. Emphasizing gas turbine construction will continue only for a time. More suitable sources must be used sooner or later. What will those be?

The Environmental Influence

Environmental forces will have a major, and possibly decisive, impact on energy choices. Economics will remain important, but only influential. The environmental problem is enormously complicated. Every activity in the world contributes to the temperature and world makeup; the sun, the atmosphere, the soils and rocks, the earth's internal forces, the plants, the animals, the oceans, and more. The items causing concern from man-made influences are acid rain, ozone depletion, and global warming.

> ***Additional capacity equivalent to approximately 200 new plants will be needed by the year 2000. How will that be accommodated?***

Acid rain is believed to be caused mostly by sulphur released to the atmosphere, which forms into sulfuric acid, a compound particularly harmful to trees and other vegetation. Power plants which burn fossil fuels, and especially coal, are the greatest contributors of sulphur. Much can be removed at the source and major efforts are being made to do so .

Ozone layer depletion is considered a grave problem because the ability of that layer to absorb the sun's ultraviolet rays is reduced. The principle cause of ozone depletion is believed to be man's use of chloro-fluorocarbons (CFCs), more commonly known as freon. Chlorine from CFCs tends to break up ozone molecules and also inhibit creation of new ozone. Action has been taken to reduce use of CFCs to a much lower level by the year 2000, though the problem will continue.

The most publicized threat is "global warming", to which the "greenhouse effect" is the main, but not sole, contributor. The earth absorbs solar radiation and reflects some energy back to the atmosphere as infrared radiation, which is absorbed by the water vapor, carbon dioxide, methane, nitrous oxide and ozone. The atmosphere, in turn, radiates some of that infrared energy back to the earth. This cycle of absorption and re-radiation is vital to the maintenance of a livable habitat on this planet. As pollutants raise the density of the atmosphere, the percentage of radiation reflected back to the earth rises. That process is the "greenhouse effect".

The theory of the greenhouse effect is well known, but much of what actually happens is uncertain. How much of an effect has man already made? Can the environment compensate and how fast? What caused freezing and thawing centuries ago? There is not enough empirical data from the past 150 years to produce reliable answers. Projected changes of a few degrees in a hundred years means the rate of change is so small that reliable measurements of world temperatures will require years of study. Highly sophisticated computer models have not been able to duplicate past history, so they cannot be regarded as reliable indicators of future developments. While many scientists are convinced global warming has begun and must be dealt with immediately, almost on a crash basis, other scientists remain unconvinced.

On the political side, however, the global warming momentum is escalating. The media has declared itself pro-environment, which means it feels justified in less-than-balanced reporting. Federal funding is growing, and with that, a building of vested scientific interests. Environmental activists find global warming a most effective cause on which to build and encourage fears. The issue is an especially attractive because it involves the entire world.

Whatever the state of knowledge, the political influence on energy choices will be substantial. Political velocity exceeds scientific velocity. But the decisions will be made anyway. As we subsequently discuss energy alternatives, it may be helpful to keep in mind relative emission values, for these will be influential.

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Using coal as a reference, how do CO_2 emissions compare:

Coal	100
Oil	81
Wood	81
Natural gas	56
Uranium	0

A Look at Alternatives

Alternatives must be examined one by one for each has different advantages and disadvantages.

Coal: Coal is abundant, competitive, and dirty. Electricity produced from coal contributes 25 percent of the world's CO_2 emissions, as well as sulphur, nitrous oxides, particulates, carbon monoxide, volatile organic compounds, methane, and other pollutants. Each pound of coal burned produces approximately three pounds of carbon dioxide. A large station may burn as much as a million pounds of coal per hour and emit three million pounds of carbon dioxide. A train load of coal can disappear into the atmosphere within a matter of hours.

> *The political influence on energy choices will be substantial. Political velocity exceeds scientific velocity. But the decisions will be made anyway.*

Oil: Oil pollutes less than coal, but only by 20 percent. Half the 16 million barrels per day used by the United States must be imported. Long-term availability is uncertain. (A generating plant is expected to require ten years for construction and operate for at least 40 years.)

Natural Gas: Natural gas is the cleanest fossil fuel, but does produce carbon dioxide, sulphur, methane, and other pollutants. Natural gas leakage is a special problem, because the methane that escapes is among the most damaging of pollutants. Expediency will require extensive use of natural gas over the next decade.

Wood: Wood was a "back-to-nature" favorite a few years ago. A popular bumper sticker, many will recall, was "Split wood, not atoms." While splitting proved benign, cutting trees and burning did not. Wood produces large quantities of carbon monoxide, particulates, organic compounds, and smoke.

Biomass: Garbage, wood shavings, cow manure, and the like are often useful for cogeneration, but their potential contribution is minor.

Geothermal: Geothermal does not require fuel, is reasonably economic, and is comparatively favorable from an environmental standpoint. However, availability in most of the United States is very limited. Geothermal supplies less than one percent of national supply, and nearly all of that is in California.

Hydroelectric Power: Hydroelectric power is clean, reliable, and economic. Six percent of the nation's power is from hydroelectric sources. Economically attractive sites are very limited and are environmentally restricted. Some small hydroelectric dams will be built, but hydroelectric sources are no longer a major contributor. Nor will they ever be again.

Solar: I recently saw a national poll in which the public was asked: "Which one energy source do you think will be our primary source of electricity ten years from now?" The three first places were nuclear–27 percent, solar–17 percent, and coal–9 percent. Why are the expectations for solar so high when its contribution is negligible and no substantial expansion is planned? Ten years is a short time. Construction alone of such facilities usually requires ten years. A significant contribution within ten years is impossible.

Solar's problems are not simply technical. Even when those are solved, as they will be, major economic obstacles remain to hinder the integration of solar into utility systems. The sun does not always shine. The public wants electricity rain or shine, night or day. A couple of examples may illustrate.

A variety of solar energy systems are being developed; one at California's Barstow station focuses sunlight on a boiler to produce steam for a conventional turbine generator. But provisions must be made for periods during which solar does not produce. A gas-fired boiler is provided for that. Think about the system that exists after a natural gas boiler is added. The generating station is equipped with two complete steam generation systems. One, the solar part, can operate part of the time. The other,

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the natural gas part, can operate virtually full time. Why not simply use the gas boiler full time? Fixed costs go on whether used or not. The savings from solar operation will be part-time fuel cost. The real function of solar becomes that of a part-time fuel saver. Justifying 30 to 50 square miles of land for collectors and solar's high capital costs, merely for fuel savings, will be difficult.

Another alternative may employ energy storage devices, such as batteries to be charged when the sun shines and discharged when circumstances require. To meet normal daytime load, and simultaneously charge batteries, would require a doubling or tripling what solar plant capacity might otherwise be needed. Again, think about that in relationship to a utility system. If battery storage is practical and affordable, why not charge with fossil, nuclear, or other already available means, during off-peak hours? Most generating plants operate at about 60 percent of capacity, but if demand were available, could operate at 90 percent. The 30 percent of unused capacity could be utilized for battery charging. So solar again competes against incremental fuel costs.

Solar is useful for remote electricity needs, heating, and other specialized applications. But the likelihood that solar will play a significant role in central station electrical power during the next several decades is remote.

Windmills: Windmills depend upon weather, require tens of square miles, are noisy, interfere with television, throw icicles, and have other disadvantages. Construction was once motivated by special tax credits, but those credits no longer exist. The system obstacles described for solar also apply to windmills. Although useful in special situations, the disadvantages preclude a major role.

Conservation: Conservation has made, and is continuing to make, an important contribution. Conservation has reduced the nation's peak demand about three percent, roughly equivalent to one year's growth in demand. In other words, conservation has avoided the need for approximately 20 generating plants. How far conservation can be used to advantage is yet to be determined. "Conservation" must be considered in several categories. The various types embrace quite different economic, social, and political principles.

Why are the expectations for solar so high when its contribution is negligible and no substantial expansion is planned?

- First, the American ethic voluntarily eliminates waste. We have an ingrained, psychological opposition to waste. We extract every last drop of toothpaste simply because of a mindset opposing waste.

- Second is free market action whereby adjustments in supply and demand take place according to price. As electricity costs have increased, demand has changed. That adjustment does not work in command economies. For example, the USSR used 3.3 times as much energy per unit of output as did Western Europe in 1984.

- Third is allocation of investment. Investments may be employed to reduce demand or to increase supply. For example, rather than investing in facilities to provide heat for a home, that same investment might be used to insulate the home in a way that would reduce heat requirements.

- Fourth, is regulation. Specifications introduced through the legal or regulatory system may reduce energy requirements, whatever the consequence. For example, building codes may specify insulation requirements, and thereby eliminate choices.

- Fifth, is "coercive utopianism" where measures are taken to promote a particular ideology. One way involves creation of shortages; shortages lead to rationing; rationing leads to government control; government control leads, so the elite believe, to administration by the "good"; and administration by the "good" will lead to social changes.

I encountered an example of "coercive utopianism" at a recent conference to discuss whether nuclear power should be revitalized in light of global warming. Sixty or seventy specialists from various technical fields, political persuasions, and ideologies attended. At dinner one evening, a small group of us became involved in a discussion of conservation.

I offered the observation that one was justified in being conservative when planning on the results of conservation until it was clear what would actually be achieved. Excess optimism could be very costly, while excess conservatism (that is, building too far in advance of need) carried only a small cost.

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I cited what I thought was a rather convincing example, namely, the California highway situation. I recalled that Jerry Brown, when governor, stopped freeway construction on the theory that there "had to be a better solution to California's growing traffic needs than covering the state with concrete and asphalt." But Jerry never saw fit to identify it. Traffic problems grew for eight years. Solutions grew not at all. Now California has a double problem; compensating for lack of past highway construction, while attempting to cope with population growth. Despite special efforts, highway capacity is increasing only one-fifth as rapidly as needed. New taxes, among other measures, are being imposed to do some of what should have been done before. The result did not seem to me to be a desirable one.

However, a "coercive utopian" sitting next to me saw things differently. He reacted with "Ah, but Jerry Brown was right! Had his policy prevailed, people would have been forced to use mass transit, forced to ride bicycles, forced to work at home, and forced to make many other beneficial changes." Perhaps, but do we really want those choices made for us? Who is to say those changes would have been beneficial?

Nuclear Power: I have put nuclear power last on the list because the process of elimination in virtually all studies seems to focus attention sooner or later on more use of nuclear. More than 400 nuclear plants operating in 26 countries provide 17 percent of the world's total electrical generation. The 110 plants in the United States supply 20 percent of the nation's electricity. Although orders have continued in France, Japan, China, and elsewhere, an order has not been placed in the United States for 15 years. Nevertheless, many ordered before the mid-1970s have been constructed, entered service in the 1980s, and have accounted for 35 percent of new capacity the past fifteen years.

Various issues, not the least of which are waste disposal, safety, licensing, regulation, and public resistance, have contributed to the stalemate. The nuclear weapons facilities problems, though not directly related to commercial plants, have added difficulties by association.

Uncertainties have caused investors to be reluctant to invest in nuclear facilities, particularly because licensing and regulation destroys confidence in costs and schedules. Changes forced during the course of project construction have greatly increased costs and added delays. Moreover, nuclear plants especially, have been subjected to after-the-fact "prudency reviews" that have prevented utilities from recovering ten billion dollars for costs over which they had little or no control. The public is satisfied neither with the plants' safety nor with waste disposal. Chernobyl was a very major setback that will forever affect nuclear power. (Even so, Mr. Gorbachev said in 1989 that "...safety should be guaranteed. But we won't survive without nuclear power.") I'll discuss safety and waste subsequently.

A Summation: Before proceeding further I'd like to sum up where we have come. The power generation means discussed divide into several categories.

- ◆ Fossil fuels include coal, oil, and gas. Those are proven and practical, but are major contributors to atmospheric pollution.
- ◆ Nuclear fuels do not release emissions to the atmosphere, but are stymied by public attitudes.
- ◆ Hydroelectric is environmentally attractive because it does not pollute, but also environmentally unattractive because of its impact on streams and rivers.
- ◆ Renewables such as wind, solar, and geothermal, are limited in capability, and some are unproven. (Less than one percent of the world's electrical power is produced by renewables and most is geothermal.)
- ◆ Conservation has produced benefits. The easy steps may have been taken and the cost of achieving future results may increase. Limits remain to be tested.

Those are the choices. I think it is clear that when one realistically considers the alternatives, as many have done, more use of nuclear power is unavoidable. Only the timing remains uncertain. Future generations simply will not forego that immense energy resource while fossil fuel problems grow and the nation needs the energy.

Nuclear Safety

As promised, I'd like to expand on nuclear safety. Some hold strong views that are probably not resolvable; I include those who believe nuclear power should not be utilized for one or more of the following reasons.

- ● Plutonium is bad and any systems which produce it should be banned. *I believe that plutonium can be dealt with—in fact, it is already here and being dealt with.*
- ● All radiation is bad and systems which produce it should not be permitted. *The fact is that radiation is a natural phenomenon that we cannot avoid.*

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- A Chernobyl-type accident is probable in the United States and risks outweigh possible benefits. *While an accident is always a possibility, American-type reactors and US regulatory procedures reduce risk to minimal levels.*
- Nuclear power should be opposed simply because it is nuclear power. *This quasi-religious resistance to nuclear power is not a rational point of view that will prevail with time. There is, as I say, no point in dwelling on those issues, because much is based on faith or intuition and probably not resolvable.*

Concerns related to safety and waste can be approached more rationally. Without TMI and Chernobyl—mainly Chernobyl—nuclear power's problems would be far, far less. Those two events were watersheds, although of different magnitudes. TMI was a financial and public relations disaster. It was not a complete technical disaster nor health disaster. The ultimate protection provided in the design proved adequate. Not a single person was injured, nor was property damaged outside the plant itself.

Chernobyl, in contrast, was a complete disaster in every respect. The figure first announced by the Soviet government of 31 people killed is certain to be low. Financial consequences to surrounding territories will be far greater than first admitted. Radiation releases caused extensive external damage. The basic technical concept was chosen to produce weapons material and electrical power; this compromise reduced safety. Containment according to Western standards was not provided. Operational practices were inadequate. Secrecy precluded proper post-accident actions. All would have been unacceptable in the USA.

The record on energy programs wholly dominated by government demonstrates that few succeed.

Nuclear safety must, nonetheless, be improved. The public wants more safety and the industry has accepted the challenge. Passively safe and inherently safe concepts are being developed which depend upon natural laws for control and cooling, and much less upon operators and equipment.

Waste Disposal

Erroneous perceptions about nuclear waste abound. The high-level radioactive waste generated in the reactor core is the most radioactive and long-lived, and therefore most important. A moment of perspective on this waste may be worthwhile.

A reactor core contains several hundred fuel bundles arranged in a cylinder approximately 10 feet in diameter and 12 feet in length. The volume is approximately 1,000 cubic feet, though only a portion of that is fissionable material. An average of 20 percent is changed each year. (Termed "spent fuel" after removal.) The volume of the twenty percent removed is less than a six foot by six foot cube. Spent fuel can be stored as fuel bundles in the form removed from the reactor, as Sweden and Finland do. Although that may not be the form for final long-term storage, storage in that form is feasible for hundreds of years.

Only a few percent of spent fuel consists of radioactive fission products and plutonium. The remainder is reusable uranium. The few percent that are radioactive products can be chemically separated by reprocessing. After reprocessing, those fission products could be contained in only a few cubic feet of space. The radioactive products may then be embedded in a material such as glassified bricks for permanent storage. The French, British, and Japanese employ processes of this type.

Other means can reduce amounts of radioactive isotopes by converting them to less active, or inactive, isotopes. Certain types of reactors actually "burn" fission products. A combination of reactors may also be used to reduce the total number of spent fuels with which waste handlers need be concerned. The combination of reactors can operate in tandem, with fuel elements first used by a reactor of one type and then reused in a reactor of another type. The number of "double duty" spent fuel elements requiring storage or processing is thus reduced.

One reason the national waste program has not proceeded more rapidly is a lack of physical urgency. (Different than public relations urgency.) Thirty years of spent fuel is already being stored at certain power plant sites. One hundred years could probably be stored if really necessary. The federal government has assumed responsibility for final spent fuel disposition and charges utilities one-tenth of a cent per kilowatt hour for the service. The government trust into which the fees are paid has reached six billion dollars. DOE selected a storage site in Nevada, spent five hundred million dollars of that fund, decided what has been done is inadequate, and a new start is being made.

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The "nuclear waste problem" has never been clearly defined. What an acceptable solution would be in the eyes of some is not known. If radioactive wastes must be made completely non-radioactive in a short time, that may be impossible. (Which, of course, is why some nuclear power opponents argue that it is necessary.) If it is enough to provide safe storage, then solutions are already in place. And if the intermediate storage as the Nevada facility will provide is acceptable, that too should constitute a solution. The lack of definition of "acceptable" will continue to plague the industry until resolved.

> *Apply taxes in a manner that takes account of after-use costs to society . . . A "carbon dioxide tax" may be one consequence.*

California

I think it may be worthwhile to look at the situation in California, for California is often a national trend setter. California voters will be asked to vote in November 1990 on a referendum containing many environmental restraints, one of which is that carbon dioxide emissions must be reduced 20 percent by the year 2000. What might be the implications?

California is part of an integrated Western electrical power market that includes Oregon, Washington, and, to a lesser extent, other Western states and British Columbia, Canada. California annually requires approximately 50,000 megawatts of electrical energy. Half is produced from oil and gas, 15 percent from nuclear, 20 percent from hydro, 10 percent from coal, and 4 percent from geothermal. A cutback in carbon dioxide limits may affect the fossil portion, or about 60 percent of the total. If fossil fuel use were reduced 20 percent, 6,000 megawatts (equivalent to six to twelve typical power stations) might be removed from service.

The ultimate impact is not clear. California is a state with a growing demand for electrical energy for uses of all types. Moreover, California will add six million people in the next decade. Air pollution is already a major problem—perhaps greater than any other state—so the need is for more widespread use of electrical energy.

To reduce pollution in areas such as Los Angeles, electric automobiles have appeal. But the electric automobile will require more generating capacity, which may be difficult in the face of a fossil fuel cutback. For example, switching one million autos (about five percent of California's present number) to electricity would require roughly 3 to 6 additional 1,000 megawatt power stations. The number is unknown, partly because it would depend upon how users recharge. I recall that Japan's peak power requirements were once largely determined by the tiny electric rice cooker. Each required only a small amount of energy, but when millions were plugged in at dinner time, peak demand soared.

Search for a National Energy Strategy

In July 1989, President Bush directed the Secretary of Energy to submit to the President, by December 1990, a national energy plan based on the following guidelines.

1. Develop an energy strategy through the year 2030 that can be implemented as soon as possible, rather than waiting until the next energy crisis.
2. Formulate the program so that it will create national consensus.
3. Build on market reliance, rather than coercion.
4. Take a "can do" approach; capitalize on US scientific knowledge and common sense.

My Suggestions

What would I suggest if I were advising Energy Secretary Watkins? The following are a few thoughts.

Assume continued electrical growth: History shows that electrical demand has continued growing despite cost increases, conservation, and other retarding factors.

Fossil fuel use: Anticipate continued fossil fuel use. Support technological advances, but recognize that carbon dioxide cannot be contained and will remain a concern.

Conservation: Press forward with conservation. Make economically feasible changes. Very importantly, learn the limits of conservation.

Global Warming: Go slow until scientific study more accurately determines how large the actual problem is, and the time scale for dealing with it. Emphasize research and development with that objective. In the meantime, however, do what is practical to discourage further increases in carbon dioxide emissions.

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Tax Schemes: Apply taxes in a manner that takes account of after-use costs to society, much like that already employed for nuclear fuel. A "carbon dioxide tax" may be one consequence.

Nuclear Option: Proceed with a nuclear power plant prototype construction program designed to bridge the period from the present to a probable much larger need in ten years. Make one objective to have available licensed, standardized, proven, and tested designs by the year 2000. Make a second objective that of completing licensing and regulatory reform. Make a third objective that of restructuring supplier and user organizations for a reorganized industry.

Nuclear Waste: Initiate a bold, comprehensive, coherent, nuclear waste program based on President Bush's "can do" attitude.

Power Plant Siting: Develop plans compatible with *anticipated* rather than *past* siting conditions. Most of the USA's 70 sites accommodate only one or two units. But public attitudes have changed since those selections were made. Fewer sites will gain acceptability and must be used to maximum advantage. Like in France and Japan, power generation capacity will need to be concentrated. Effective utilization of large sites means multiple, standardized units, common auxiliary systems and service facilities, and more extensive fuel handling provisions. New thinking at the conceptual level is needed.

Private Industry: Although government financial and regulatory support is essential, programs must be controlled and implemented by private industry. The record on energy programs wholly dominated by government demonstrates that few succeed.

Imagination: In addition to ground rules outlined in President Bush's directive, add extensive use of imagination. For example, with nuclear, approach reactor design, plant design, siting, waste storage, waste processing, and community acceptance, as a single comprehensive challenge, rather than a series of isolated problems.

Conclusion

The moment of truth for electrical energy policies in the USA may soon arrive, just as it did in Sweden. How will we respond? For how long will we continue emphasizing gas turbines as an expedient solution? Will we adopt what some claim to be a "painless path" and rely on technologies and means not yet proven? Will we accept shortages? A decline in the standard of living? Government imposed rationing? These are among the fundamental questions that must be faced sooner or later.

My belief is that we must continue the "hard path"—that is, relying on what we know will work and not what we hope will work—until proven, workable, superior alternatives are available. Electricity is the heart of the American industrial system and far too important to be tinkered with based on theory rather than experience. ■

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RAW MATERIALS

THE CROW BUTTE PROJECT NEARS PRODUCTION

The Crow Butte Mining Project received its permit to construct from the Nebraska Department of Environmental Control (NDEC) on April 24, 1990, making it Nebraska's first uranium production project. The permit opened the way for the commercial development of what is likely to be one of the USA's lowest-cost uranium producers.

Initial Discovery

The project was initiated in 1978 when Wyoming Fuel Company, a subsidiary of KN Energy, Inc., noted that Nebraska's geological records showed weak radioactivity in oil and gas wells and a favorable geology for uranium deposits. Other major uranium mining companies had conducted grass-roots uranium exploration in Nebraska previously, but had not found any evidence to encourage exploration. The following year, Wyoming Fuel formed a joint venture with Ferret Exploration Company, Inc. Wyoming Fuel was designated as the project operator. The joint venture acquired a regional lease position on 64,000 acres in the Sioux and Dawes counties of Nebraska.

Reconnaissance exploration led to the discovery of uranium reserves near the town of Crawford in 1979 and 1980. Estimates put the reserves at more than 25 million pounds equivalent U_3O_8, with an average grade exceeding 0.25 percent. Further exploration in 1981 and 1982 confirmed the initial estimates, and also indicated additional reserves of an equal amount and grade outside what was to become the Crow Butte Project's permit area, but within the Crow Butte Joint Venture properties and the adjacent Big Red properties.

Project Ownership Changes

In 1986, Wyoming Fuel divested itself of its 50-percent share in the project. Ferret Exploration of Nebraska, Inc. (FEN—a 96-percent subsidiary of Ferret Exploration Company) became the owner/operator of the project. Since 1987, the project has been owned by Ferret Exploration Company/First Holding Company/Geomex Minerals, Inc. (65%), Korea Electric Power Corporation (10%), and Uranerz USA, Inc. (a wholly-owned subsidiary of Uranerzbergbau GmbH of West Germany—25%)

Licensing

FEN submitted a pilot plant permit application to the US Nuclear Regulatory Commission (NRC) in early 1983. The NRC approved a 100 gallon-per-minute (gpm) pilot plant in 1985. The pilot plant's construction was essentially completed in that same year and pilot operations began in mid-1986. Crow Butte purchased the state-of-the-art Trevino in-situ leaching (ISL) plant (**Figure 1**) from Conoco in 1987. FEN moved the entire plant from Texas to the project site, located about four miles southeast of Crawford, Nebraska. Late in 1987, the project submitted applications to the NRC and NDEC for commercial operating licenses.

The NRC issued its license in December 1989; however, the project encountered a delay in Nebraska. The Western Nebraska Resources Council (WNRC) opposed the project and resurrected a century-old Nebraska law which limits foreign ownership of land or leases to less than 50 percent interest. The Nebraska attorney general initially found that the project constituted a majority foreign-owned enterprise. The Crow Butte Project owners then made sufficient organizational changes to satisfy the Nebraska state attorney general. The NDEC issued its license permitting commercial production in April 1990, following the state attorney general's revised ruling in favor of the joint venture.

Project Construction

Using three drill rigs, the project is installing the initial well-field of 120 wells (**Figure 2**), configured in both five-spot and seven-spot arrangements. Pilot plant results suggest uranium recovery rates of 72%-84%, which will be

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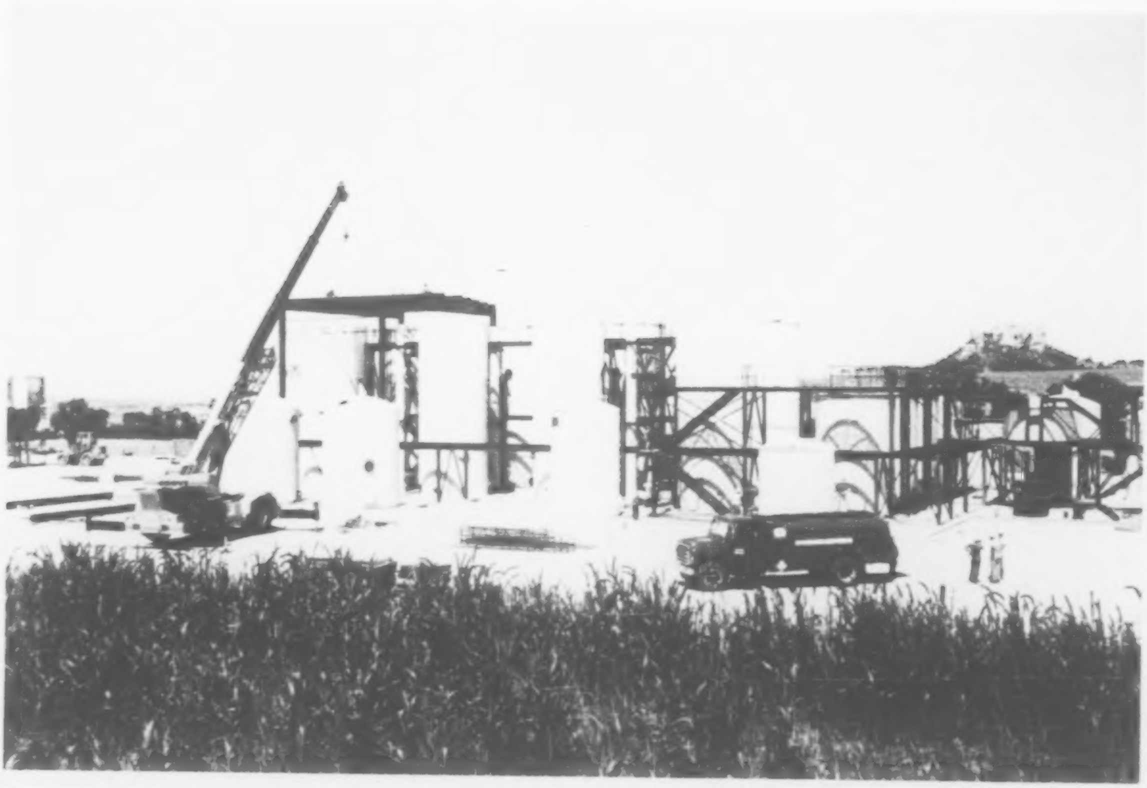

Figure 1 — The Crow Butte Project's uranium processing (ISL) plant, located four miles southeast of Crawford, Nebraska. The 2,500 gallon-per-minute plant was purchased from Conoco in 1987, and moved from its Texas site. Crow Butte, for which the project is named, can be seen in the background, to the right of the plant.

determined by well spacing and duration of leaching. Well flow rates averaging 30-50 gpm (gallons-per-minute) are expected with the average solution grade exceeding 60 ppm (parts-per-million).

The processing plant is currently under construction within the 2,500-acre permit area. Commercial production is scheduled to begin in the first quarter of 1991, at about half of the plant's one-million-pound annual capacity (2,500 gpm). Expansion to a two-million-pound annual capacity (5,000 gpm) can be accomplished with minimal expenditures when market conditions warrant. The plant will employ about 30 people and annually contribute over one million dollars in salaries to the area's economy.

Although the plant is licensed for a yellowcake dryer, near-term plans call for the uranium to be shipped in slurry form. The small amount of low-level waste that the plant will generate will be shipped off-site to a commercial waste facility.

Geology

The Chadron Sandstone hosts the uranium mineralization which precipitated as a roll front along the oxidation-reduction interface of bleached and reduced (chemically) sands. The host formation varies in thickness from 25 feet up to almost 100 feet. The Chadron Sandstone occurs as a continuous unit throughout the trend with minimal claystone and mudstone beds.

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The project has the potential to produce at relatively low cost for several reasons primarily related to the site's geology. Most of the high-grade material is deposited in the base of a highly permeable sandstone formation. Although these deposits, at 400 to 850 feet deep, are slightly deeper than those normally recovered through ISL, the low volume of mudstone and clay-stone coupled with the high artesian water pressures combine to contribute to high flow and recovery rates. Moreover, the uranium is concentrated in one depth range, rather than the more common arrangement of smaller amounts at various levels separated by non-ore bearing layers of material. Finally, the reserves are spread very evenly through a nearly continuous six-mile trend, thereby improving potential wellfield efficiency and flexible production.

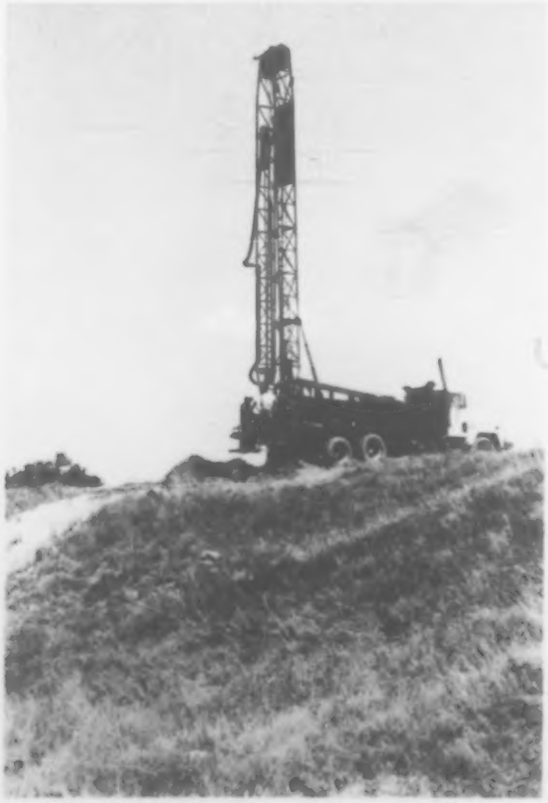

Figure 2 — A drill rig is prepared to drill one of the Crow Butte Projects's 120 initial ISL wells.

Production

Additional cost savings will be realized during the initial years of operation because well fields are close to the processing plant. Rather than employ the satellite concept utilized by many other uranium solution mines, the pregnant lixiviant will initially be piped directly to the processing facility. This approach will reduce capital expenditures as well as labor requirements during the first five to six years of commercial operation.

Another difference will be the utilization of solar evaporation ponds rather than a deep disposal well.. Two such ponds are being constructed during the initial phase, with three additional ponds planned for expanded operations.

FEN's near-term focus emphasizes cost saving in order to enhance project viability. The acquisition and refurbishment of the Trevino leach tanks and processing equipment will contain initial capital costs to less than $8.0 million. The Crow Butte reserves should allow an operating life of over 20 years. Under these conditions, the project may have production costs of less than $10 per pound U_3O_8. ■

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CZECHOSLOVAKIA'S NUCLEAR POWER AND FUEL PROGRAMS

Thomas C. Pool, NUEXCO's Supply Analyst, prepared the Uranium Production portion of this article, using photos and other information obtained while in Czechoslovakia earlier this year. During his around-the-world trip, he also toured uranium production facilities in Yugoslavia and the People's Republic of China.

Czechoslovakia has been one of Eastern Europe's most active uranium producers for more than 40 years and has an ambitious nuclear power program that extends into the 21st century. However, changing COMECON relationships, rapid internal political changes, capital constraints, and newly-expressed concerns about nuclear safety have left all plans open to examination and alteration.

Background

Czechoslovakia, with a surface area just under 50,000 square miles, is slightly smaller than the US state of New York. With nearly 16 million people, Czechoslovakia has Eastern Europe's fourth largest population and the second-highest population density. The country's has two distinct ethnic groups: Czechs comprise about two-thirds of the population and Slovaks the remaining one-third.

The Communist Party, which had been in control of the country since World War II, stepped down from power in November 1989. An interim government, with Vaclav Havel as president, promptly took office and scheduled free elections for June 1990. Acting president Havel won a two-year term, as more than 96 percent of the eligible voters participated in Czechoslovakia's first free election in over 40 years.

The new government has the responsibility for creating a national constitution. The Havel government has already progressed toward the creation of a market-driven economy.

- By withdrawing from the COMECON (Council for Mutual Economic Assistance) currency agreements, the government adopted the use of hard currency in all international trade.
- The government reached an accord with the EC, which will gradually eliminate trade barriers between Czechoslovakia and the EC member states.
- As of May 1, 1990, foreign participation in Czech companies is allowed and unrestricted.

The government also renamed Czechoslovakia the *Czech and Slovak Federal Republic*, to give equal prominence to the country's two ethnic groups.

NUCLEAR POWER PROGRAM

Energy Demand

Czechoslovakia estimates that its economy will demand 86 billion kWh in 1990, nearly twice the level of 1970, and that its annual energy demand will reach 117 billion kWh by 2000. Delays and possible closures of nuclear plants could cause supply to fall as much as 16 billion kWh short of the 2000 demand estimate. The country has long relied upon coal to supply its energy requirements. Czechoslovakia has no oil and gas resources, and hydro power can only satisfy a small percentage of annual electricity demand. Coal fueled 87 percent of electrical generation in 1980, and will provide about 56 percent in 1990.

But Czechoslovakia estimates its coal reserves will only last for another 30-60 years at current production rates. Even those production rates cannot be relied upon because a large share of the remaining coal reserves are difficult to access. Additionally, the investment required to obtain those reserves would be unjustified. These rapidly dwindling coal reserves have forced the government to reduce the country's coal dependence and select new sources of energy.

Czechoslovakia does not want to depend on foreign sources of energy, because payment now must be made in hard currency. The country already depends on the Soviet Union for all its oil and natural gas requirements. The use of natural gas as the new fuel source would also necessitate the inclusion of allowances for expensive, major modifications of the gas transport and distribution systems to handle the volumes required.

If oil were chosen as the new fuel source, Czechoslovakia would need to find a new supplier. The Soviet Union has been supplying the 16.6 million metric tons of oil that Czechoslovakia has required annually.

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However, the Soviet Union is cutting back all exports of oil, including exports to COMECON countries (totalling 78 million metric tons in 1989), by 7.0 million metric tons this year, because it is concerned about possible fuel shortages at harvest time. The Soviet Union's oil output is suffering both from a shortage of production equipment, and from worker slowdowns (in an attempt to win economic concessions from the government). In July and August of this year, Soviet oil deliveries to Czechslovakia fell short of the agreed levels by 400,000 metric tons. Czechoslovakia's government sees an expansion of its nuclear program as the only reasonable option, because the country has skilled industrial capabilities and abundant, developed uranium resources.

Energy conservation could help reduce Czechoslovakia's energy demand, but substantial conservation through the application of energy-efficient industrial equipment would prove quite expensive. Czechoslovakia is Eastern Europe's most industrialized country and the world's fourth most energy-intensive. Industry consumes over three-fourths of the country's energy production and utilizes old, inefficient equipment. Almost one-third more electricity is used in Czechoslovakia to produce a ton of steel than in France or West Germany, despite Czechoslovakia's use of old, open-style coal furnaces, rather than newer, electric furnaces. The World Bank ranks Czechoslovakia as one of the two most energy-inefficient countries in Europe. Czechoslovakia's own data shows that western economies require up to 50 percent less energy to produce an equivalent amount of gross national product.

Economics

The availability of capital is Czechoslovakia's major limiting factor in developing its energy programs. Accelerated development in all sectors of the economy, a result of economic and political restructuring, is straining the national budget. Energy production and expansion already consume one-third of the country's industrial funds, which equates to 12-13 percent of the country's annual expenditures. The installation of efficient, modernized equipment will require massive investments of capital and time. Much of the technology to backfit and improve industries may need to come from the West, which will consume a greater share of the limited supplies of hard currency.

Environmental

Environmental concerns have helped reinforce the government's interest in nuclear power. Czechoslovakia has the second highest level of industrial pollution per square mile in the world, and is one of the European countries most affected by acid rain. Many of these pollutants are produced in the mining and use of coal. A recent poll indicated that the environment is the number one public concern. With the public's new freedom of expression, vocal, pro-environment groups have arisen. The Havel government is also quite concerned about the environment. However, the government does not appear to be softening its pro-nuclear position, despite anti-nuclear demonstrations and vocal opposition to the continued operation of the VVER-440 reactors.

Czechoslovakia's government, both past and present, had hoped to reduce pollution by retiring coal-fired power plants as nuclear plants came on line. However, delays in the plans and schedules for the nuclear plants will keep the government from retiring 2,000 MWe of coal-fired capacity by 2000, and another 1,500 MWe by 2010. Over the next ten years, the nuclear plant delays will cause an 11-percent increase in carbon dioxide, a 67-percent increase in sulfur dioxide, an 8-percent increase in nitrous oxide, and a 44-percent increase in fly ash particulates, as compared to the target levels previously set.

Current Nuclear Power Plants

The Czechoslovakian firm of Skoda, Eastern Europe's largest industrial firm and Eastern Europe's only constructor of Soviet-licensed reactor designs, began construction of Czechoslovakia's first nuclear reactor in 1958. Bohunice A-1, a 110-MWe (net) heavy-water-moderated, carbon-dioxide-cooled demonstration reactor, was the result of a joint Soviet/Czech project that began in the early 1950s. Bohunice A-1 (also known as CS-1) began commercial operation in December, 1972. Authorities decided to retire the reactor in 1979 after an employee's error had caused a partial core meltdown two years earlier.

The Bohunice site now has four 408-MWe (net) VVERs (Vodo-Vodyanoi Energetichesky Reaktor: a water-cooled, water-moderated Soviet-designed reactor, similar in concept to a Western PWR). Bohunice-1 and -2 began commercial operation in 1981, and are first generation VVER-440s (the number '440' indicating the reactor's

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440-MWe gross rating). The first generation VVER-440 (model V230), the earliest export model offered by the Soviet export agency Atomenergoexport, is based on the Soviet Novovoronezh-3 reactor developed in the late 1970s. Bohunice-3 and -4 commenced operation in 1985, and are second generation (model V213) VVER-440s (incorporating added safety features over the first generation model). Four more second generation VVER-440s started commercial operation at the Dukovany site during the period 1985-1987 (**Table 1**). Since that time, nuclear power has supplied over one-fourth of Czechoslovakia's electricity needs.

Four 388-MWe (net) second generation VVER-440s are under construction at the Mochovce site and these units are expected to enter commercial operation in the mid-1990s. At the Temelin site, two 892-MWe (net) VVER-1000s are under construction and are also targeted for commercial operation in the mid-1990s. The VVER-1000 is another Atomenergoexport model, and is based on the Soviet Novovoronezh-5 reactor design. Three Czechoslovakian firms supplied the majority of equipment and construction in all the country's VVERs.

- *Skoda Works* produces pressure vessels, steam generators, small pumps, turbine generators, pressurizers, pipes, and fittings;
- *Vitkovice Zelezarny* produces steam generators and pressurizers;
- *Sigma* produces small pumps and fittings.

Czechoslovakia's former government had planned to build at least another 17 nuclear units by the year 2000, allowing nuclear power's share of electricity generation to reach 60 percent by the year 2005. The ambitious plan included two VVER-1000s each for the sites of Kecerovice, Blahutovice, Opatovice, and Temelin (in addition to Temelin's two VVER-1000s already under construction). It also included four more second generation VVER-440s for the Mochovce site. Havel's government is currently reassessing all reactor plans because of capital limitations and safety concerns.

Government Organizations

The new government recently assumed control, from the Soviet Union, of the safety programs for Czechoslovakia's nuclear stations. The Ministry of Energy and Fuels is responsible for the operation of all energy production, including nuclear-powered heat and electricity. This ministry has recently been integrated into the Federal Ministry of Economics, but this article will continue to refer to the Ministry of Energy and Fuels when discussing events that took place before the reorganization. The Czechoslovakia Atomic Energy Commission handles regulatory matters, much like the US Nuclear Regulatory Commission; it also conducts research and development, and specialized production, such as radionuclides. Additionally, Czechoslovakia belongs to Interatomenergo, an international organization that has assumed responsibility for VVERs built since 1985 in countries outside the USSR. Interatomenergo, headquartered in Moscow, conducts planning, coordinates production, and

Table 1
NUCLEAR POWER UNITS

Reactor	Type	MWe Net	COD[1]
Operating			
Bohunice–1	VVER	408	1981
Bohunice–2	VVER	408	1981
Bohunice–3	VVER	408	1985
Bohunice–4	VVER	408	1985
Dukovany–1	VVER	408	1985
Dukovany–2	VVER	408	1986
Dukovany–3	VVER	408	1987
Dukovany–4	VVER	408	1987
Under Construction			
Mochovce–1	VVER	388	1993
Mochovce–2	VVER	388	1994
Mochovce–3	VVER	388	1995
Mochovce–4	VVER	388	1996
Temelin–1	VVER	892	1994
Temelin–2	VVER	892	1996
Plans Under Review			
Blahutovice-1	VVER	892	—
Blahutovice-2	VVER	892	—
Kecerovice-1	VVER	892	—
Kecerovice-2	VVER	892	—
Mochovce–5	VVER	388	—
Mochovce–6	VVER	388	—
Mochovce–7	VVER	388	—
Mochovce–8	VVER	388	—
Opatovice-1	VVER	892	—
Opatovice-2	VVER	892	—
Temelin–3	VVER	892	—
Temelin–4	VVER	892	—

[1] COD = Actual or Expected Commercial Operation Date

coordinates and performs design work. The organization, created in a 1979 agreement, also includes Bulgaria, East Germany, Hungary, Poland, and Romania. Just this May, Czechoslovakia joined Italy, Hungary, and Yugoslavia in a group called the Pentagonal Initiative. This group cooperates in economic and cultural matters, and has just added energy to its areas of cooperation. Czechoslovakia suggested the addition of energy, so its representative will chair the energy working group.

Safety Issues

The new government, in its role as the guardian of safety at Czechoslovakia's nuclear sites and stations, has initiated several inspections by international organizations. Two such inspections of the Temelin site reviewed both siting criteria and quality/safety-related aspects. The two inspection teams made recommendations for a number of improvements, but determined that the Temelin site still met recommended IAEA international standards related to their inspections.

Despite the safety inspections, both the Austrian government and Czechoslovakian environmental groups have repeatedly voiced two major concerns about safety. First, the Soviet-designed reactors at Bohunice, Dukovany, and Mochovce lack containment vessels. Second, the reactors at these three sites are VVER-440s, as are the Loviisa units in Finland and the Greifswald units in East Germany, which have had numerous, significant, and widely-publicized problems. For example, design defects have produced accelerated thermal embrittlement of steel and welds in the reactor vessels. In addition, inspectors (which included Czechoslovakian officials) acknowledged that the safety standards of these *first-generation* 440-MWe VVERs "are inadequate with respect to modern safety technology."

However, the Ministry of Energy and Fuels has claimed that its reactors have improved designs, are made of better materials, and are built to higher quality-control standards than the Loviisa and Greifswald units, which were built by the Soviets with Soviet materials. The Ministry has also stated that about 80 percent of the construction and components of the Czechoslovakian VVER-440s are supplied by Czechoslovakian firms. However, conflicting information leaves open the possibility that either Bohunice-1 or -2, or both, have Soviet-constructed, rather than Skoda-constructed, reactor vessels. The Ministry of Energy and Fuels also points out that Bohunice-1 and -2 are its only first generation units, and they were built about five years later than the troubled Finnish and East German units, thereby allowing the incorporation of numerous, improved safety features.

Some support for these claims comes from the recent inspection of the Paks first generation VVER-440s in Hungary. The Paks units have Skoda-built reactor pressure vessels, which were inspected with the same methods that discovered the thermal embrittlement problems at the Loviisa units. The inspection determined that thermal embrittlement should not be a problem during the Paks station's operational life.

The Ministry of Energy and Fuels has defended the idea that its VVER-440s do not require the immediate shutdowns that East Germany determined its Greifswald units required, following an inspection by West Germany's Gesellschaft fuer Reacktorsicherheit mbH. Still, the Ministry does not contend that its reactors, both VVER-440 and VVER-1000, do not need improvements. In fact, the Ministry of Energy and Fuels has recently been renegotiating its contract, with the Soviet Union's Techsnabexport, to reschedule fuel supplies for Temelin-1 and -2. The rescheduling is needed because of problems with core-instability, which was discovered in similar VVER-1000 plants operating in the USSR and Bulgaria, and which necessitates compensating revised burnup rates and refueling schedules.

The recent political reforms in Czechoslovakia have offered its government and firms the opportunity to approach a number of Western companies about supplying technology. Specifically, Czechoslovakia's government is interested in obtaining western instrumentation and control (I&C) technology for its nuclear reactors, such as those at the new Temelin station. Havel's government has recently committed to the installation of western I&C technology in all reactors currently in operation or under construction, with the exception of Bohunice-1 and -2 which remain in the forefront of debate. The Atomic Energy Commission estimates the costs to backfit the Bohunice, Dukovany and Temelin sites at over US$1.0 billion.

Austria's Prime Minister Franz Vranitzky is particularly opposed to the continued operation of the Bohunice site, because of the safety issues and the site's location, which is only 60 miles from Vienna. He has even offered financial assistance in shutting down the Bohunice site, and has offered electricity (at a cost of nearly US$6.0 million) to offset much of that which Czechoslovakia would lose from shutting down the site for a week of inspections.

Following a July 30 meeting in Vienna, between officials

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from the Austrian government, and officials from Czechoslovakia's Atomic Energy Commission and Federal Ministry of Economics, Czechoslovakia's government has decided to supply Austria with safety-relevant documentation on Bohunice-1 and -2, and to offer Austrian officials an examination of the site. Czechoslovakia will also have two IAEA teams inspect the Bohunice site in October. If the IAEA teams recommend closure of Bohunice-1 and -2, Czechoslovakia's government has agreed to comply with that recommendation. Should the IAEA teams not recommend closure of the two reactors, and if the reactors continue in operation beyond a couple more years, both will receive backfits of western I&C technology.

The reactors at Mochovce were to have used a new Czechoslovakian-developed, multi-computer system known as Deris. The Deris system was designed to be controlled by a high-level Soviet system. However, the total system has not met reliability standards and a decision is currently being made as to whether the Deris system will be improved with, or replaced by, western I&C technology. If the Deris system is replaced, it will probably be used to control auxiliary plant systems instead.

Fuel Cycle

All of Czechoslovakia's fabricated nuclear fuel has been purchased from the Soviet Union. Until recently, the Soviet Union had agreed to accept the return of spent fuel without additional charge, because the costs were included in the price Czechoslovakia paid for the fabricated fuel. However, the Soviet Union has now announced that it will institute charges for this return service, and payments must now be made only in hard currency. The charges could be as high as $1,200 to $1,300 per kilogram uranium. Because of the additional financial burden these charges impose (possibly $16 to $20 million per comparable PWR core reload), Czechoslovakia's government is considering possible sites for its first long-term waste storage site. Consideration is being given to the use of the Bohunice A-1 reactor pool, or, as there are no salt formations, a granite site near the border between the districts of Bohemia and Moravia. Czechoslovakian officials have also held discussions with Cogema regarding the reprocessing of spent fuel.

A recent twist was added to this issue when the new president of the Russian Republic, Boris Yeltsin, proclaimed that he would refuse to allow foreign (apparently non-Russian) spent fuel and wastes into Russia. Russia contains all the USSR's fuel cycle facilities, including those used for fuel reprocessing and storage. President Yeltsin has not clarified whether his announced ban applies to existing contracts, or only to any future contracts. Though Mikhail Gorbachev, President of the Soviet Union, has repudiated Yeltsin's ban, the additional uncertainty of this possible ban has further hastened Czechoslovakia's waste storage planning.

Future Plans

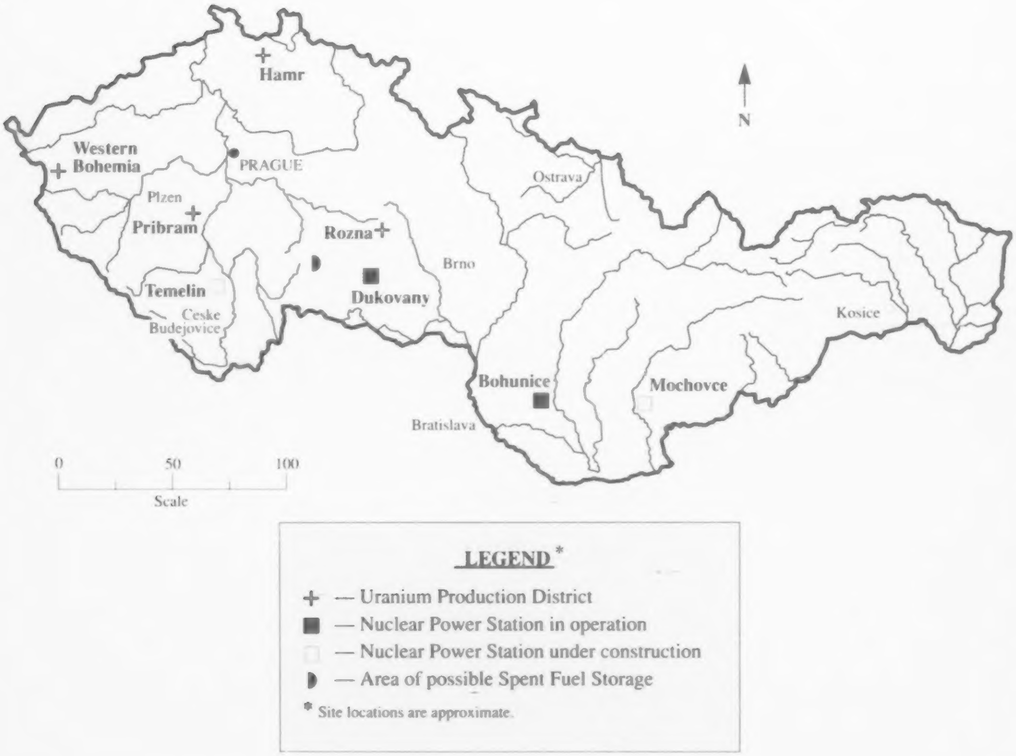
Czechoslovakia's energy planners are considering Western-designed PWRs for any new nuclear plants that may be built. They are even considering replacing the two VVER-1000s under construction at Temelin with western PWRs of 600 MWe to 1000 MWe (gross) capacity. Such considerations of western I&C technology or full western designs may revive construction of Temelin-3 and -4. At present, Havel's government has put a hold on all planned reactors, in particular Kecerovice, Blahutovice, and Opatovice, for new assessments of safety, both of the sites and of the reactor designs, plus the economics involved in such a large-scale plan. The government remains strongly committed to nuclear power, but the events since November 1989 have introduced an entire reevaluation of timetables, economics, safety, and sources, and the final results of that reevaluation cannot yet be discerned.

URANIUM MINING

Czechoslovakia's uranium industry has been in the forefront of East European uranium production since its inception after World War II. The historic Jachymov mine, which produced radium in the early 1900s, provided much of the country's initial uranium production. However, other deposits were soon discovered and developed.

Through the early 1960s, all of Czechoslovakia's uranium production was directly controlled by the Soviet Union. Much of the labor utilized at that time was provided by prisoners or inmates of forced labor camps. Following that period, uranium was produced under contract to the USSR, but Czechoslovakia had only very limited influence in defining the terms of such contracts. A recent renegotiation and extension of these arrangements will allow the sale of at least some portion of Czech uranium production in the international market place.

Figure 1
CZECHOSLOVAKIA
NUCLEAR POWER PLANTS AND FUEL CYCLE FACILITIES


Hamr
N
Western Bohemia
PRAGUE
Ostrava
Plzen
Pribram
Rozna
Brno
Temelin
Dukovany
Ceske Budejovice
Kosice
Bohunice
Mochovce
Bratislava
0
50
100
Scale
LEGEND*
+ — Uranium Production District
■ — Nuclear Power Station in operation
□ — Nuclear Power Station under construction
◗ — Area of possible Spent Fuel Storage
* Site locations are approximate.

The *Československý uraňový prümsyl, koncern* (CSUP) directs and administers Czechoslovakia's uranium industry. CSUP is organized into 11 divisions: four mining, four processing, one research and development, one concerning civil works construction, and a general administration division. CSUP employs almost 20,000 people.

Czechoslovakian uranium production will be decreasing in the near- to mid-term as resources at many older mines are exhausted or as the increasing depth of mine workings force costs to higher levels. These operational changes, along with the political changes now sweeping the country, will ultimately result in a restructuring of the Czech uranium industry, along leaner, more competitive lines.

Presently, Czechoslovakian uranium producing activities are focused in four principal areas: Pribram, Rozna, Western Bohemia, and Hamr.

Pribram Uranium District

The Pribram uranium district is located 30 miles south of Prague in a major metal mining area that has been active since the Middle Ages, when lead and silver were the primary products. Today, Pribram is the headquarters of CSUP and is honeycombed with ventilation and hoisting shafts for one of the world's most prolific uranium deposits.

Pribram's mining history has been traced back to 1311, when gold placers were operated under the rule of John of

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Luxembourg. Succeeding centuries saw alternating periods of prosperity and decline. In 1779, the world's first deep mine was developed at Pribram. By 1875, this mine had reached a depth of over 3,000 feet and Czechoslovakia had become a world leader in mining technology. In the 1890s, the rapid decline in silver prices and a disastrous underground fire which claimed over 300 lives were crippling blows to Pribram's economy. In 1947, however, discovery of large deposits of radioactive minerals gave the district new life. Mine development was initiated shortly thereafter and uranium production commenced in 1950. More than 10 individual mines were operating during the peak production period, which occurred in the 1960s. One of Pribram's mines is still operating today, which makes it longer-lived than any uranium mine in the west.

Geology

The uranium deposits of the Pribram district occur in a series of steeply-dipping, hydrothermal veins within an elongated area measuring fifteen miles in length and one mile in width. These veins are hosted by weakly metamorphosed Upper Proterozoic sediments, mostly schists, which have been folded, faulted, and intruded by paleozoic granitoids and a wide variety of dikes. Several thousand veins have been identified in the district; over 1,600 have been mined for uranium.

Pribram's uranium-bearing veins are typically extensive (300-3,000 feet) both vertically and laterally, but are generally thin with widths ranging from 0.5 to 40 inches, and exhibit a distinct mineral zoning of calcite, siderite, sulfides, and the uranium minerals—pitchblende and anthraxolite. The vertical extent of the uranium mineralization within the vein system exceeds 6,000 feet.

Mining

During its 40-year history, the Pribram mine complex has compiled an impressive list of statistics:

- The mine workings include over *1,500 miles* of horizontal openings and 26 shafts, internal and external, with a total length of over 15 miles **(see Figure 3)**.
- Over 160 million tons of ore and waste have been mined, of which almost 90 million tons have been hoisted to the surface.

Uranium production quantities have not yet been made public, but it seems likely that Pribram has produced in excess of 150 million pounds U_3O_8. At the peak of its activity during the 1960s, mine production exceeded 10,000 tons of ore and waste per day, surpassing the output of most western uranium mines by a large margin. The mining method at Pribram is principally shrinkage stoping with fill, a relatively labor-intensive method ill-suited to mechanization.

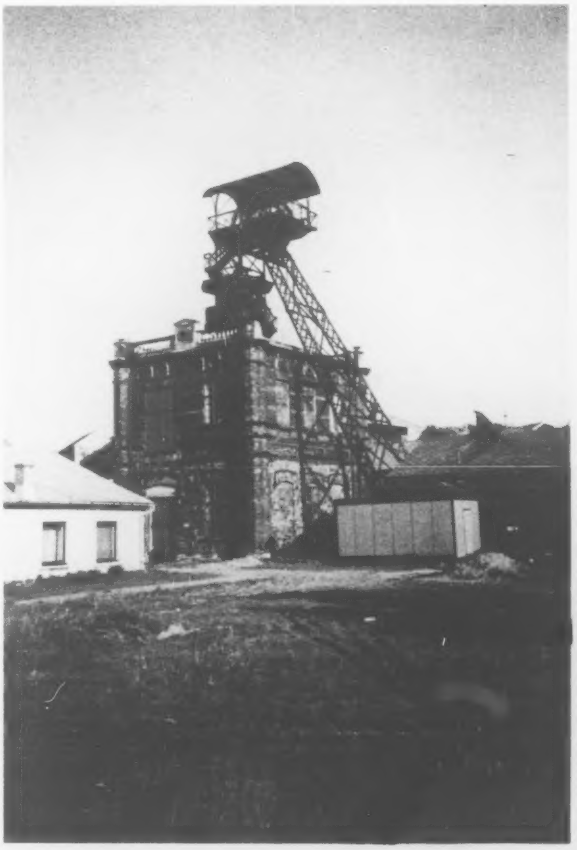

Figure 2 – This headframe in the Pribram district was constructed in the late 1800's, and is illustrative of Czechoslovakia's rich mining heritage.

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The basic sequence of operations includes:

- opening a basal drift along the vein;
- mining upwards following the vein with a minimum opening of four feet in width;
- transferring higher-grade ore through intermediate raises down to the haulage level while leaving lower-grade ore in place to serve as a working platform;
- upon completion of a mining block, withdrawing the lower-grade ore and backfilling the empty block with waste rock.

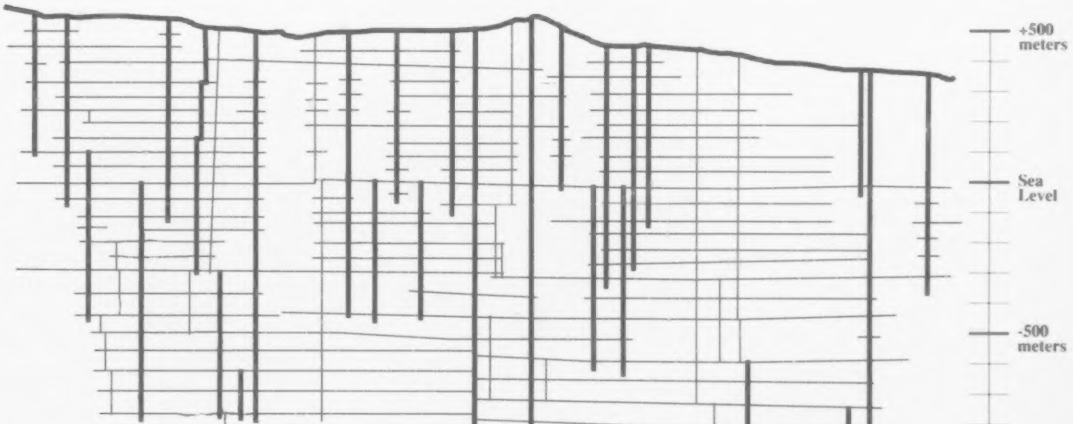
The mining blocks are served by an extensive rail haulage system. Rail cars containing higher-grade ore are hoisted to the surface six at a time. Lower-grade ore and waste is dumped into underground bins and hoisted separately by skips.

The deepest areas of active mining are now at almost 5,000 feet, a depth at which rock temperatures exceed 100°F and at which rock pressures can cause serious rock bursts. The mine is relatively dry however, and a massive ventilation system provides an adequate working environment. Current production from the Pribram mine is approximately 600,000 tons of ore per year from a work force of some 2,500 employees. Low grade ore is sorted radiometrically at a central sorting plant, which discards much of the waste fraction. The ore fraction and the higher-grade ore from the mine are shipped directly to the Soviet Union by train without further processing.

Rozna Uranium Mine

The Rozna mine is now the only operating uranium mine in the Labe Lineament uranium district, located 80 miles east of Prague. A nearby mine of similar character, the Olsi mine, was closed in 1989. Uranium mineralization within the district was discovered in 1954; the first production occurred in 1958. The original reserves of the

Figure 3
PRIBRAM MINE WORKINGS



Typical vertical section of a portion of the mine workings at Pribram. Vertical lines indicate hoisting and ventilation shafts. Horizontal lines indicate main haulage levels. The lowest level shown is #32, which is located at an elevation of more than 1300 meters (over 4300 feet) below sea level.

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Rozna and Olsi mines totaled 52 million pounds U_3O_8, but most of that reserve is now exhausted and the Rozna mine has a remaining life of only a few more years.

Geology

The Labe Lineament uranium district is located within a series of folded and faulted metamorphic rocks of Precambrian age which have been eroded to a gently rolling plain. These rocks include paragneisses, amphibolites, quarzites, and metamorphosed limestones. At the Rozna mine, uranium mineralization occurs as disseminations, or in veins and stockworks. Most mineralization is related to shear zones or other structural discontinuities. Disseminated mineralization accounted for the bulk (65 percent) of the original reserves. Pitchblende is the primary ore mineral, but in some areas it is metasomatically replaced by coffinite. In veins, the pitchblende is associated with selenides of copper, iron and lead. Ore grades vary widely from 0.05–0.10 percent U_3O_8 in the metasomatic ores, to 0.15–0.25 percent U_3O_8 in the disseminated ores, to 0.30–0.75 percent U_3O_8 in the vein ores. The main ore zone is one mile long and extends to a depth of 4,000 feet. Individual ore lenses are commonly 7 to 10 feet wide and 60 to 70 feet in vertical extent.

Mining

The Rozna mine has been developed on 24 levels with two main hoisting shafts, three auxiliary shafts, and two internal shafts. Ore production amounts to 600,000 tons per year. The primary mining method, employed to control the very weak ground, is an underhand stoping method termed "top-slicing." The top-slicing method, as implied by name, is based on the removal of successive horizontal slices from the top of the ore. After a slice of ore is removed, the remaining waste rock and debris overlying the mined zone is allowed to collapse onto the floor of the zone. In order to insure the integrity of the roof for the next slice, this floor is overlain with a mat of wire and timber before the collapse is initiated.

Each stoping area is operated by a three-man crew utilizing jackleg drills and two-drum slushers. Round, native timber provides most of the ground support. Ore is hauled to the shafts by means of diesel locomotives pulling 2.6-ton ore cars which are dumped into loading pockets. A 17-foot-diameter Koepe hoist is used to bring 16.5-ton ore skips to the surface at a maximum speed of 2,400 feet per minute. The mine is well-ventilated with an airflow of almost one million cubic feet of fresh air per minute.

Ore from the Rozna mine is processed on site at the Diamo mill to produce yellowcake. Overall employment at the Rozna/Diamo production center totals 3,000 including 700 miners, 500 underground support personnel, 150 mill operators, and a supervisory staff of 100. Electrical consumption for the mine, mill, and townsite amounts to 150 kilowatt hours per ton of ore mined.

Western Bohemia Uranium District

The Western Bohemia uranium district is located in western Czechoslovakia, near the border of West Germany. Radioactive minerals were first discovered in the district during the 1920s when sources of radium were being sought. No development ensued, however, and the district languished until the late 1940s when interest in uranium brought renewed exploration. The first mine in the district, Zadni Chodov, was developed in the early 1950s. Vitkov II followed, and the third mine, Dylen, was developed in 1963. A number of other prospects and occurrences have been identified. The original uranium reserves of the district exceeded 30 million pounds equivalent U_3O_8.

Geology

Uranium deposits of the Western Bohemia district, extending 15 miles north/south along the border with West Germany, are associated with a system of north/south trending fault zones. The deposits are localized at or near the contact between Proterozoic (Moldanubian) metasediments and Paleozoic granitoids. Two types of ores are characteristic of the district:

- disseminated ores in episyenites;
- narrow veins in strongly-altered wall rocks.

Coffinite and brannerite are the principal uranium minerals; pitchblende is a minor constituent. At the Vitkov II deposit, uranophane and uranium phosphates are developed to depths exceeding 2,000 feet. Ore grades are generally in the range of 0.12 to 0.35 percent equivalent U_3O_8. The vertical extent of the ore lenses generally far exceeds the lateral extent, and mineralization has been identified to depths exceeding 4,000 feet.

Mining

The underground mines of Western Bohemia are developed by vertical shafts and a series of horizontal levels to depths ranging from 2,000 to 2,500 feet. Levels are now spaced at about 200-foot intervals and are sized to allow dual-track rail haulage for much of their extent. In the lower levels of the mine where rock temperatures reach

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97°F, refrigerated air is used to provide reasonable working conditions in development headings.

The mining method is overhand cut and fill, with two miners working each stope. At the present time, seven stopes, three development headings, and two raises are under way at Zadni Chodov, with 40 miners on each of two shifts. Total employment at the mine is 320. The Vitkov II mine is of similar size, but Dylen is somewhat smaller. Total output for the district is estimated to be about 150,000 tons of ore per year, and perhaps, 500,000 pounds equivalent U_3O_8 per year. Ore from this district is shipped by rail to the Midlovary mill in southern Czechoslovakia.

Hamr Uranium District

Hamr is Czechoslovakia's newest and currently most productive uranium district; it is also the key to the future of the Czechoslovakian uranium industry. The district, located 45 miles north of Prague, was discovered in 1963 and has seen the development of two underground mines and one in-situ leaching (ISL) project. The smaller underground mine, Osecna, will be closed in the near-term, but the larger mine, Hamr, will continue in production.

Geology

The Hamr uranium district covers an area of almost 100 square miles and includes at least eight uranium deposits of varying size. These deposits occur in an uplifted block of Cretaceous sandstones which is underlain by Proterozoic metasediments and granites. Mineralization occurs in Cretaceous sandstones, mostly in the basal units and predominantly in scour channels, in fault-bounded depressions, and at contacts with Tertiary volcanic dikes. Overlying the ore sandstones is a relatively impermeable layer of clayey sandstone. Ore depths range from 500 to 1,600 feet.

Ore grade mineralization is typically rather thick, ranging from about 15 to 40 feet cumulative thickness in several zones to as much as 100 feet in eleven different horizons. Ore grades range from a 0.04 percent equivalent U_3O_8 cutoff for ISL production to as much as 1.0 percent U_3O_8 in isolated pods of redistributed ore. The average ISL grade is about 0.12 percent U_3O_8, while the grade at the Hamr underground mine is about 0.18 percent U_3O_8.

The ore minerals include sooty pitchblende, coffinite, ningyoite (a uranium, calcium, rare earth phosphate), and a uraniferous metacoloidal zircon. The latter mineral represents a substantial fraction of the uranium content, and is particularly refractory; a circumstance which has contributed to low uranium recovery.

Total resources of the Hamr district have been estimated to be as high as 520 million pounds U_3O_8, but this would include a significant quantity of lower-grade (less than 0.10 percent U_3O_8) mineralization which may not be economically recoverable. Nevertheless, this total resource marks Hamr as a major uranium district which can make a measurable contribution to world production.

Mining

The Hamr underground mine and the Straz ISL project are immediately adjacent, a situation which causes some hydrologic difficulties, because an underground mine can be operated more efficiently (particularly in sandstone) if it is dry, and ISL production requires a saturated ore zone. The current solution to this dilemma has been the construction of a hydrologic barrier between the two tracts. This barrier consists of 150 water injection wells in a 4.3-mile-long dividing zone. The injection rate is 4,200 gallons per minute. This injection provides a saturated ore zone for the ISL project, but adds to the already burdensome 9,500 gallons-per-minute pumping requirements for the underground mine. Drainage sublevels have been constructed in the basement rocks underlying the mine, but muddy conditions in the ore horizon still create a major operating problem.

The Hamr underground mine has been developed from vertical shafts on two levels: an upper mining level in the ore horizon and a lower (150 feet) haulage level. The mining method is panel and fill, wherein rooms (panels) 16 feet in width and height are driven at a 16-foot spacing for the full length of the ore zone (which is normally 200 to 400 feet). Upon completion, these panels are backfilled with a sand/cement mixture by specially-designed conveyor trucks. After the sand/cement mixture hardens, the intervening pillar can be removed and backfilled in a similar manner. Rubber-tired diesel equipment is used in the ore horizon, while diesel rail equipment is used on the sublevel. Ground support in the panel access drifts is principally steel sets with corrugated steel sheet lagging. Within the panels, splitset rock bolts and wire mesh provide protection for the miners. The ventilation rate is 780,000 cubic feet per minute. The mine production rate is 2,200 tons of ore per day with about 1,200 employees, 600 of whom work underground.

The Straz ISL project has been in operation for 17 years and has been the scene of a great deal of research and development as various wellfield geometries and chemical/hydrological/recovery schemes have been tested. Currently, the project is operated with a sulphuric acid lixivient, primarily a line drive geometry for injection and recovery wells, and ion exchange recovery. Under the line drive geometry, recovery wells are located on 330 foot centers and injection wells are located on 36-foot centers. The injection and recovery lines (up to 5/8 mile in length) are spaced at intervals of 250 feet. A major consideration in the use of this geometry is its amenability to concurrent agricultural use. Acid strength in the injection solution varies from 20 to 100 grams per liter, and the recovery grade is maintained in the range of 20 to 50 ppm by reducing, through time, the injection rate from 42,000 gallons per day per acre to as low as 2,100 gallons per day per acre. The wellfield is designed for a life of approximately 20 years.

The first wellfield at Straz is now ready to be reclaimed, having recovered in excess of 50 percent of the original reserve. This relatively low recovery is attributed to much of the uranium being tied up in siltstones of low permeability, and to the presence of the zirconium minerals.

Overall, NUEXCO estimates that the Straz project handles a fluid flow of about 10,000 gallons per minute, to produce about 1.5 million pounds equivalent U_3O_8 per year. This rate qualifies Straz as more productive than any ISL project in the USA.

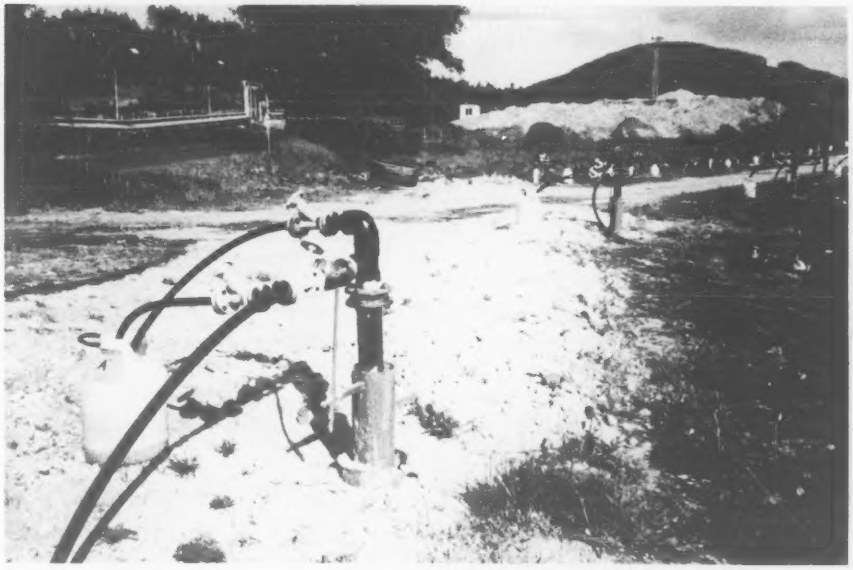

Figure 4 – In-Situ Leaching well field at the Straz ISL Project.

CONCLUSION

As many of Czechoslovakia's older uranium mines are exhausted, and in view of the political changes now sweeping the country, the country's uranium industry is likely to be restructured along more competitive lines. The nuclear program is under great public scrutiny. Safety requirements must be determined and the technology or equipment to provide that safety must be funded.

Despite the obstacles, Czechoslovakia is steadily proceeding with its nuclear program and remains firmly committed to nuclear energy to provide the electrical generation it will require in the 21st century. ■

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NUCLEAR INDUSTRY CALENDAR

1990

Sept. 13	***The New Currency: How to Capitalize on Air Emissions Credits*** (Watergate Hotel, Washington, DC). Sponsored by The Energy Daily. Contact: Lissa Wilson at 202-662-9728.
Sept. 13-14	***The Ninth Annual Nuclear Conference: "STANDARDIZATION: Can it Save the Nuclear Industry?"*** (Stouffer Concourse Hotel, Washington, DC). Sponsored by McGraw-Hill Nuclear Publications. Contact: McGraw-Hill at 1-800-223-6180 (in NY state: 212-512-6410)
Sept. 16-19	***Uranium Seminar '90*** (Hyatt Regency, San Antonio, Texas). Sponsored by the USCEA. Contact: USCEA Conference Office at 202-293-0770.
Sept. 23-26	***AMC Mining Convention*** (New Orleans, Louisiana). Contact: American Mining Congress at Suite 300, 1920 N Street N.W., Washington, DC 20036, or by facsimile at 202-861-7535.
Sept. 23-28	***ENC '90 Congress & Exhibition*** (Lyon, France). Organized by the European Nuclear Society in collaboration with the ANS and Foratom. Contact: Dr. P. Feuz, European Nuclear Society at 31-21 61 11.
Oct. 14-16	***World Nuclear Fuel Market Annual Meeting*** (Toulouse, France). Contact: Donna Cason at 404-447-1144.
Nov. 11-14	***Nuclear Energy Forum*** (Washington Hilton, Washington, DC). Sponsored by the USCEA and ANS. Contact: USCEA Conference Office at 202-293-0770, or ANS Meetings Department at 312-352-6611.
Nov. 12-16	***First Regional Seminar for Europe and the Middle East on Quality Management for Nuclear Power Projects*** (Prague, Czechoslovakia). Sponsored by the IAEA. Contact: Conference Service Section, IAEA, P.O. Box 100, A-1400 Vienna, Austria.

1991

April 14-18	***Third International Conference on Nuclear Fuel Reprocessing & Waste Management*** (Sendai, Japan). Sponsored by the Atomic Energy Society of Japan and the Japan Atomic Industrial Forum, co-sponsored by the American Nuclear Society and the European Nuclear Society. Contact: Japan Atomic Industrial Forum at 3-508-2411, or by facsimile at 3-508-2094.
May 13-15	***Second International Conference on Transportation for the Nuclear Industry*** (Bournemouth, England). Contact: Conference Secretary, The Institution of Nuclear Engineers at 081-698 1500.

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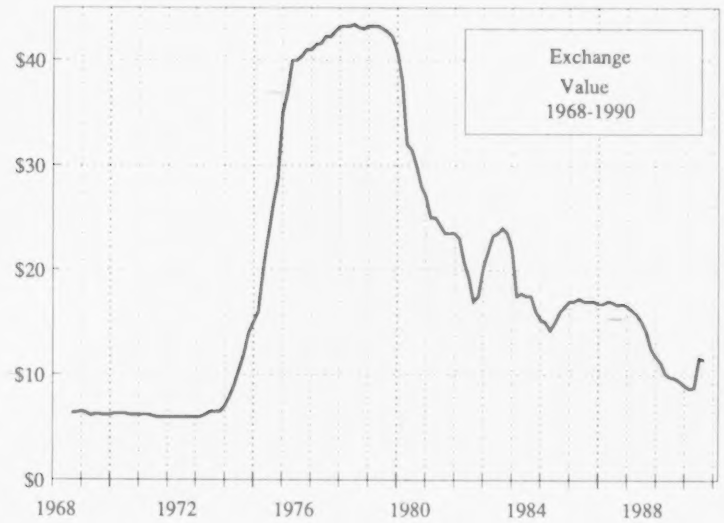
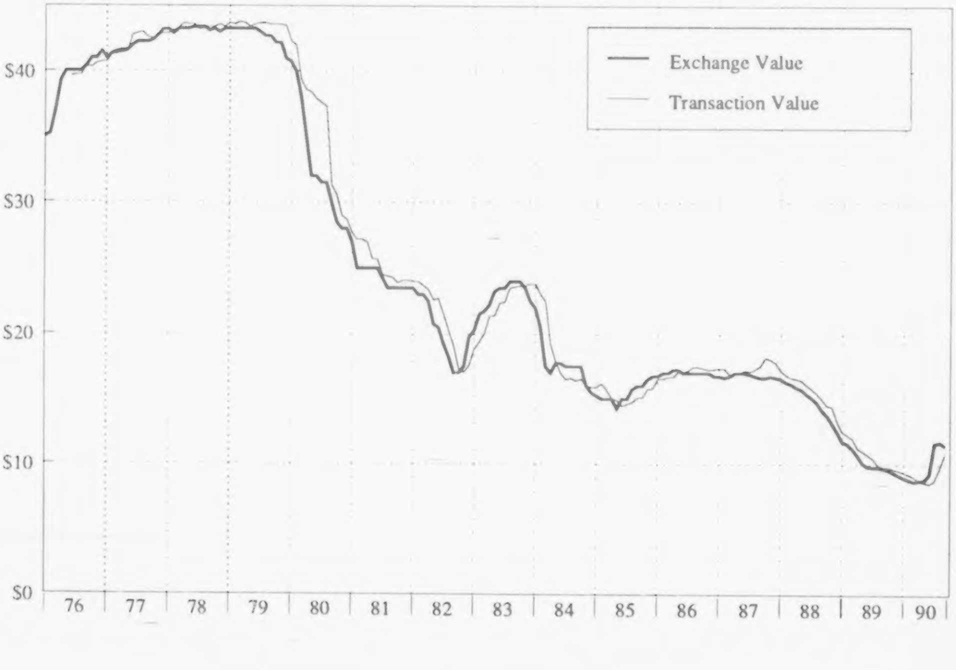
NUEXCO Historical Exchange Value and Transaction Value

(In US Dollars per Pound Equivalent U3O8)





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HISTORICAL MARKET VALUES

EXCHANGE VALUES

Determined as of the last day of the month indicated (\$US/lb U_3O_8)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	16.75	16.65	16.65	16.75	16.65	16.55
1988	16.30	16.15	15.90	15.75	15.40	15.10	14.75	14.15	13.75	13.15	12.50	11.75
1989	11.60	11.20	10.70	10.10	9.85	9.80	9.80	9.70	9.60	9.40	9.20	9.00
1990	8.85	8.70	8.80	8.80	9.25	11.60	11.70	**11.45**				

US PREMIUM (Relative to the Exchange Value)

Determined as of the last day of the month indicated (\$US/lb U_3O_8)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	0.65	0.75
1987	0.85	1.00	1.50	1.50	0.90	0.60	2.50	2.35	2.10	1.65	0.85	0.65
1988	0.70	0.50	0.15	0.25	0.60	0.00	0.00	0.00	0.00	0.00	**Discontinued**	

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UF6 VALUES

Determined as of the last day of the month indicated ($US/kg U as UF_6)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	47.50	47.00	46.75	47.00	47.00	47.00
1988	46.50	46.00	45.50	45.25	44.75	44.00	42.75	41.00	40.75	39.00	37.50	35.50
1989	34.75	34.00	33.00	30.50	30.25	30.25	30.00	29.75	29.75	28.25	27.75	26.50
1990	25.90	25.25	24.40	24.40	25.50	32.00	32.50	**32.25**				

US UF6 PREMIUM (Relative to the UF6 Value)

Determined as of the last day of the month indicated ($US/kg U as UF_6)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	2.50	2.50
1987	2.50	2.50	3.50	3.00	2.25	1.75	6.50	6.00	4.25	3.10	2.25	2.00
1988	1.25	1.25	0.50	0.50	1.00	0.00	0.00	0.00	0.00	0.00	**Discontinued**	

TRANSACTION VALUES

Determined as of the last day of the month indicated ($US/lb U_3O_8)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	17.30	17.55	18.20	18.05	17.80	17.20
1988	16.85	16.65	16.55	16.45	16.10	15.80	15.45	15.00	14.50	14.40	13.30	12.50
1989	12.25	12.00	11.25	11.00	10.75	10.45	9.95	9.80	9.80	9.65	9.55	9.40
1990	9.25	9.05	8.75	8.65	8.55	8.80	9.75	**10.80**				

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HISTORICAL MARKET DATA

LOAN RATES

Determined as of the last day of the month indicated (Percent per Annum)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	4.00	4.00	4.00	4.00	4.00
1969	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00	6.00	6.00	6.00	6.00
1970	6.00	6.20	6.40	6.50	6.50	6.50	6.50	5.00	6.50	6.00	5.50	5.50
1971	5.00	4.75	4.75	4.75	5.00	5.25	5.25	5.25	5.25	5.25	4.50	4.50
1972	4.00	4.00	4.00	4.50	4.50	4.50	5.00	5.00	5.00	5.00	5.00	5.00
1973	5.50	5.50	5.75	5.75	6.00	6.25	7.00	7.00	7.00	7.00	7.50	8.00
1974	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
1975	8.00	7.00	7.00	7.00	7.00	6.50	6.50	6.50	6.50	6.50	6.50	6.50
1976	6.50	6.50	6.50	6.50	*	*	*	*	*	*	*	*
1977	*	*	*	*	6.50	6.50	6.50	6.75	7.25	7.25	7.25	7.25
1978	7.25	7.00	7.00	7.00	7.00	7.50	7.75	7.75	7.75	7.00	7.00	7.00
1979	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1980	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1981	7.00	7.00	7.00	7.00	7.00	5.50	5.50	5.50	5.50	6.00	6.00	6.00
1982	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1983	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1984	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1985	6.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
1986	5.00	5.00	5.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
1987	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00	3.50	3.50
1988	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
1989	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
1990	3.50	3.50	3.50	3.50	3.50	3.50	3.50	**3.50**				

* Float with Prime Rate

CONVERSION VALUES

Determined as of the last day of the month indicated ($US/lb U as UF6)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.90	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.90	1.90	1.90
1988	1.90	1.80	1.80	1.80	1.80	1.80	1.85	1.95	1.95	1.95	1.95	1.95
1989	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.90	1.90	1.80	1.75	1.65
1990	1.50	1.50	1.45	1.45	1.45	1.45	1.45	**1.45**				

SWU VALUES

Determined as of the last day of the month indicated ($US per SWU)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	80	80	80	80	75	78	78	78	78	78	80	80
1987	80	80	77	77	75	73	75	75	73	69	73	73
1988	73	73	70	68	68	68	68	65	65	65	65	65
1989	65	67	67	67	66	66	66	65	63	59	57	54
1990	54	50	50	50	50	50	50	**50**				

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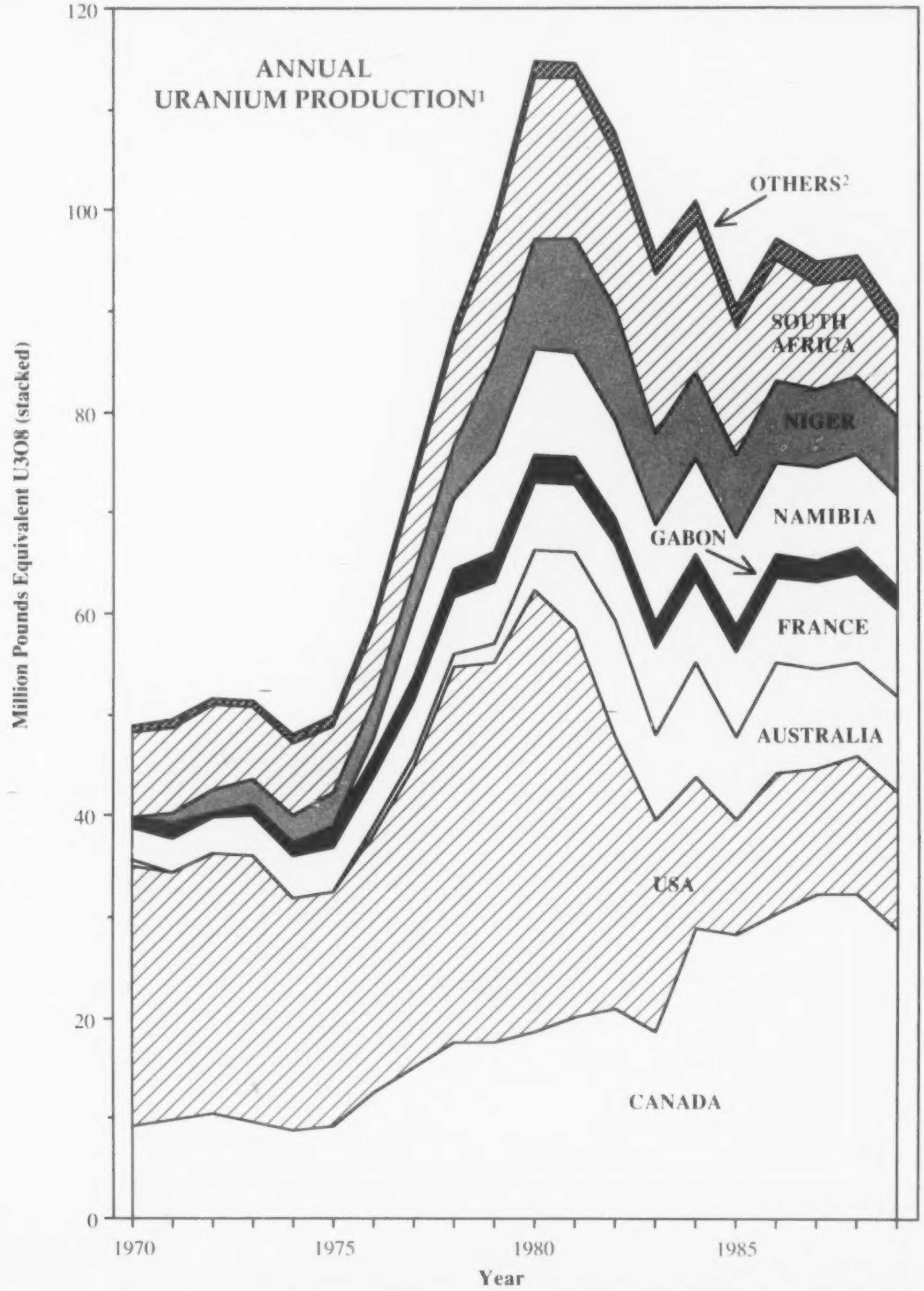

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[1] Estimated world production in 1989 totalled 89.6 million pounds (Australia—9.5; Canada—28.7; France—8.5; Gabon—2.2; Namibia—9.2; Niger—7.7; South Africa—7.7; USA—13.7; Others[2]—2.3).

[2] **Others** includes: Argentina, Belgium, Brazil, India, Pakistan, Portugal, Spain, West Germany and Yugoslavia

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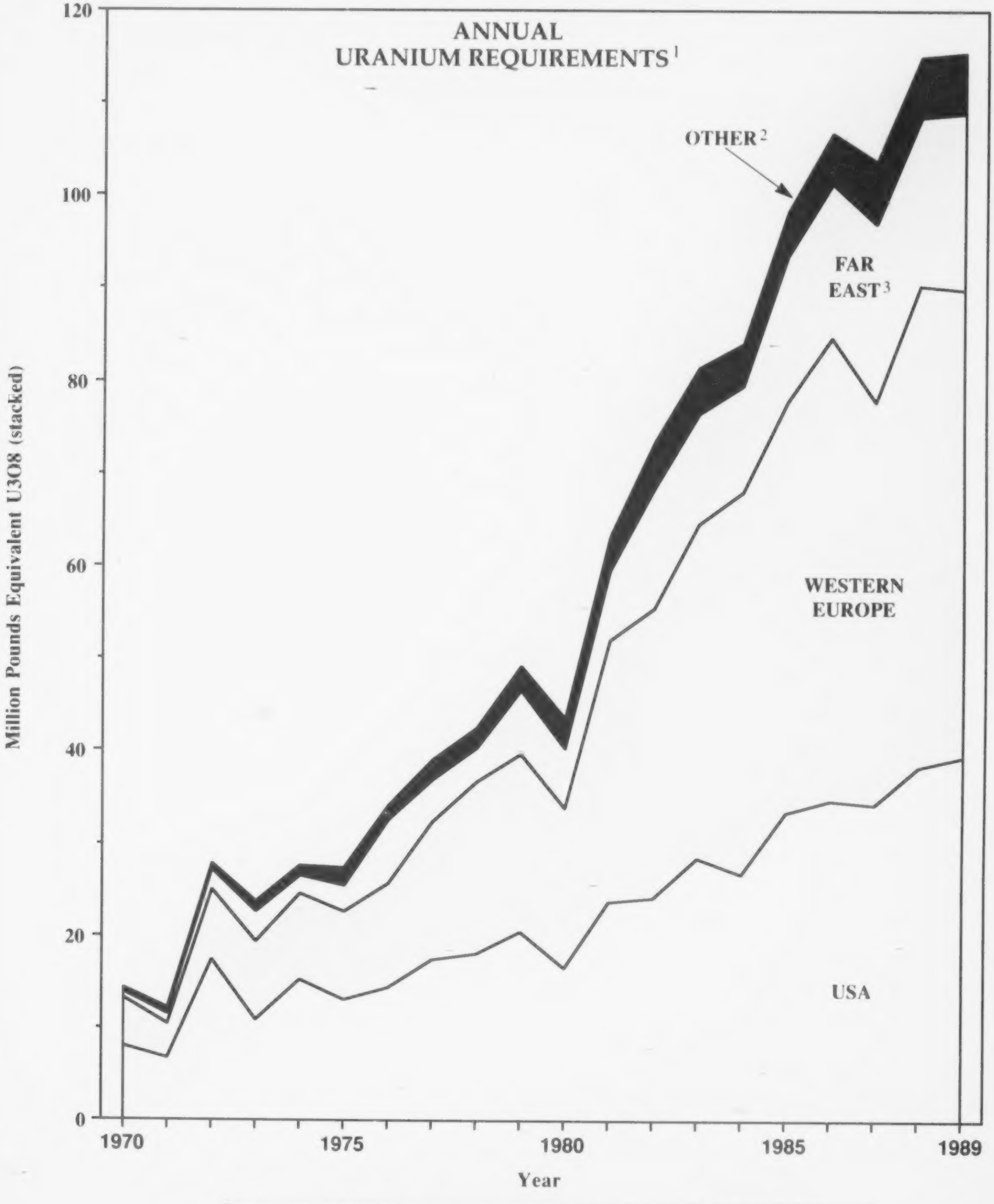

[1] Calculated by NUEXCO based on actual completion dates and operating performance, and NUEXCO's estimate of enriching tails assays.

[2] **Other** include: Argentina, Brazil, Canada, India, Mexico, Pakistan and South Africa.

[3] Does not include Peoples Republic of China.

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AUSTRALIA

Year	Period[1]	Consumer Price Index[2] (1980/1981 = 100)	Price Index of Materials Used in Manufacturing Industry — All Groups[3] (1984/1985 = 100)	Average Weekly Ordinary Time Earnings — Adult Males — Australia[4] (Australian dollars)	Award Rates of Pay Indexes Australia - Adult Males In Mining Wage Earners, Weekly Rates[5] (June 1985=100)
1980	Avg.	95.8	83.1	—	140.8[6]
1981	Avg.	105.0	85.9	—	154.1[6]
1982	Avg.	116.7	89.0	—	174.9[6]
1983	Avg.	128.5	96.9	—	181.9[6]
1984	Avg.	133.6	98.0	—	194.4[6]
1985	Avg.	142.6	107.3	—	103.7
1986	Avg.	155.5	101.5	—	106.1
1987	Avg.	168.7	108.9	465.88	112.3
1988	Avg.	180.9	111.8	496.90	115.2
1989	Avg.	194.6	117.0	534.65	126.0
Jan	1990	—	119.2	—	128.0
Feb	1990	—	120.8	—	128.0
Mar	1990	204.1	121.5	—	128.2
Apr	1990	—	119.9	—	128.5
May	1990	—	118.9	—	128.7
June	1990	—	116.6	—	—

P = Preliminary **R** = Revised since last month

[1] Monthly data for the period 1967 to 1986 appears in Report 233 (January 1988).
[2] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: Financial year July 1980 to June 1981 =100.0). Figures shown at end of quarter represent quarterly average.
[3] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0).
[4] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.
[5] Australian Bureau of Statistics, Canberra: "Average Weekly Earnings, States & Australia" (Catalogue No. 6302.0).
[6] Base: June 1976 = 100.

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CANADA

			Wage-earner Data: Average Hourly Earnings (C$)[3]				
	Industrial Products Price Index: All Commodities[1] (1981 = 100)	Consumer Price Index: All Items (1986 = 100)[2]	Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells (SIC 051-099)	Metal Rolling, Casting and Extruding (SIC 298)	Chemicals and Chemical Products Industries (SIC 372-379)
1980 Avg.	90.7	67.1	—	—	—	—	—
1981 Avg.	100.0	75.5	—	—	—	—	—
1982 Avg.	106.7	83.7	—	—	—	—	—
1983 Avg.	110.4	88.5	17.22	—	14.18	10.67	11.10
1984 Avg.	115.4	92.3	17.89	—	14.97	11.11	11.68
1985 Avg.	118.6	96.0	18.53	16.48	15.56	11.85	12.12
1986 Avg.	119.6	100.0	19.38	16.70	15.76	12.28	12.58
1987 Avg.	122.7	104.4	20.12	17.15	16.11	12.58	13.20
1988 Avg.	128.1	108.6	20.91	18.51	16.95	13.17	13.77
1989 Avg.	131.1	114.0	21.97	20.02	18.41	13.71	14.16
Jan 1990	130.8	116.9	21.88	20.39	19.03	13.99	14.78
Feb 1990	131.6	117.6	22.51	20.63	19.14	14.49	15.03
Mar 1990	131.5	118.0	22.52	20.75	19.17	14.99	15.07
Apr 1990	131.3	118.1	23.17	21.20	19.46	14.83	14.93
May 1990	131.8	118.7	23.28	20.55R	19.01R	14.71R	15.06R
June 1990	131.7	119.2	22.31P	21.12P	19.17P	14.70P	15.07P
July 1990	—	119.8	—	—	—	—	—

P = Preliminary **R** = Revised since last month

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[1] Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Monthly data for the period 1967 to 1986 is found in Report 233.

[2] New Base Year of 1986, as of Report 264. Previous Base Year was 1981. All figures in column recalculated by 0.755 multiplier.

[3] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours." Monthly data for the period 1983 to 1986 is found in Report 233.

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SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled[1] (Rand)	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled[2] (March 1982 = 100)	Consumer Price Index[3] (1985 = 100)	Production Price Index All Groups[4] (1985 = 100)	Total Employment in Mining and Quarrying[5]	Total Salaries and Wages in Mining and Quarrying[5] (1,000 Rand)
							Annual Total[6]
1980	Avg.	35.53	—	51.9	55.2	709,042	2,237,689
1981	Avg.	41.89	—	59.8	62.7	722,918	2,756,928
1982	Avg.	47.25	104.2	68.6	71.4	702,041	3,181,584
1983	Avg.	51.88	115.0	77.1	79.0	700,901	3,563,282
1984	Avg.	58.95	130.3	86.0	85.6	711,511	4,134,390
1985	Avg.	68.76	151.6	100.0	100.0	724,587	4,778,612
1986	Avg.	80.22	177.9	118.6	119.5	756,637	5,767,950
1987	Avg.	95.01	223.1	137.7	136.2	751,864	6,911,395
1988	Avg.	106.69	241.1	155.4	154.1	705,355	7,774,054
1989	Avg.	116.65	273.0	178.2	177.5	700,360	8,833,934
							Monthly Total
Jan	1990	—	—	192.0	188.8	688,837	801,616
Feb	1990	—	—	193.3	190.3	674,026	767,274
Mar	1990	126.74	296.3	196.4	190.9	684,251	762,303
Apr	1990	—	—	198.3	194.1	696,107	810,474
May	1990	—	—	200.4	196.3	—	—
June	1990	128.25	299.87	201.8	197.0	—	—
July	1990	—	—	203.2	—	—	—

P = Preliminary **R** = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly. Historical Data by month appears in Report 236.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Central Statistical Service, Pretoria: All income groups-weighted average. Historical Data by month appears in Report 236.

[4] Central Statistical Service, Pretoria: All commodities for consumption in South Africa.

[5] Central Statistical Service, Pretoria: Historical Data by month appears in Report 236.

[6] Annual total is shown, rather than monthly average for indicated year.

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GOVERNMENT STATISTICS

UNITED STATES

		Producer Price Index[1]				Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4]			
		Industrial Commodities (1982 = 100)	All Commodities (1982 = 100)	Consumer Price Index[2] (1982-1984 = 100)	GNP Implicit Price Deflator[3] (1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980	Avg.	88.0	89.8	82.4	85.7	10.26	10.63	8.30	6.94
1981	Avg.	97.4	98.0	90.9	94.0	11.55	11.98	9.12	7.62
1982	Avg.	100.0	100.0	96.5	100.0	12.31	12.93	9.96	8.21
1983	Avg.	101.1	101.3	99.6	103.9	12.58	13.43	10.58	8.67
1984	Avg.	103.3	103.7	103.9	107.7	13.05	13.43	11.07	9.04
1985	Avg.	103.7	103.2	107.6	110.9	13.38	13.74	11.56	9.46
1986	Avg.	100.0	100.2	109.6	113.9	12.46	13.48	11.98	9.65
1987	Avg.	102.6	102.8	113.6	117.7	12.52	12.98	12.37	9.88
1988	Avg.	106.3	106.9	118.3	121.7	13.09	13.22	12.67	10.13
1989	Avg.	111.6	112.2	124.0	126.6	13.67	13.75	13.06	10.38
Jan	1990	114.1	114.9	127.4	—	13.75	13.95	13.31	10.50
Feb	1990	113.6	114.4	128.0	—	13.75	13.98	13.24	10.54
Mar	1990	113.2	114.2	128.7	129.7	13.85	14.04	13.30	10.58
Apr	1990	113.1	114.0	128.9	—	13.91	14.32	13.49	10.58
May	1990	113.3	114.5	129.2		13.95R	14.10R	13.43R	10.64R
June	1990	113.1	114.2	129.9	130.9	13.91P	14.25P	13.47R	10.71R
July	1990	113.2	114.3	130.4	—	—	—	13.56P	10.78P

P = Preliminary **R** = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents. Historical data is presented in Report 233.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items. Historical data is presented in Report 233.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted. Historical data is presented in Report 233.

[4] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Historical data is presented in Report 233.

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VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]

(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3] Average Price		Spot Contracts[3] Average Price	
			in ECU per pound U_3O_8	in US Dollars per pound U_3O_8	in ECU per pound U_3O_8	in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00
1986	12,000	9.5	ECU 31.50	$31.00	ECU 18.00	$17.75
1987	14,000	17.0	ECU 28.25	$32.50	ECU 15.00	$17.25
1988	12,500	4.5	ECU 26.92	$31.82	ECU 13.65	$16.13
1989	13,500	11.5	ECU 26.63	$29.35	ECU 11.04	$12.19

R = Revised

[1] The twelve European Community member nations are Belgium, Denmark, France, West Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EEC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar. Exchange rates are published by European Communities Statistical Office and the International Monetary Fund.

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GOVERNMENT STATISTICS

US URANIUM MARKETING ACTIVITIES STATISTICS

(Compiled from data published by the US Energy Information Administration)[1]

Year	Total Production (million pounds U_3O_8)	Deliveries to Domestic Utilities From US Suppliers[2] (million pounds U_3O_8)	Average Price of Delivered Uranium[2] (\$/lb. U_3O_8)	Quantity of Uranium Imported[3] (million pounds U_3O_8)	Average Price of Imported Uranium (\$/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	27.6	$16.10	3.6	n/a	1.2
1977	29.9	27.8	$19.75	5.6	n/a	4.0
1978	37.0	31.6	$21.60	5.2	n/a	6.8
1979	37.5	33.0	$23.85	3.0	n/a	6.2
1980	43.7	35.0	$28.15	3.6	$43.10	5.8
1981	38.5	32.6	$34.65	6.6	$32.90	4.4
1982	26.9	23.5	$38.37	17.1	$25.19	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3
1986	13.5	18.9	$30.01	13.5	$20.07	1.6
1987	13.0	20.8	$27.37	14.8	$19.14	1.0
1988	13.1	17.6	$25.65	15.8	$19.03	3.3

[1] Sources: 1976-1983: US Department of Energy/Energy Information Administration, *Survey of United States Marketing Activity*
1984-1988: Energy Information Administration, *Uranium Industry Annual*

[2] Data for 1976-1981 includes both domestic utilities and agents

[3] Includes imports by domestic utilities and domestic suppliers

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INTERNATIONAL ADVISORY COMMITTEE

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USA

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South Africa

Lars Halle
Sweden

James C.C. Stewart
United Kingdom

REPRESENTATIVES

JAPAN:

Kazuo Yokota
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telefax: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

SOUTH AFRICA:

Chris I. Von Christierson
Southern Prospecting (Pty) Limited
Mailing Address:
Post Office Box 61409
Marshalltown 2107
Republic of South Africa
Street Address:
7th Floor, Marshall Place
66 Marshall Street
Johannesburg 2001
Telephone: (27-11) 834-4211
Telefax: (27-11) 834-6343
Telex: 4-89878-SA

TAIWAN:

Dr. Steve H.K. Wang
Southeast Engineering Corporation
Yu-Ming Mansion
7, Roosevelt Rd., Sec. 1, 7th Floor
Taipei, 10757, Taiwan R.O.C.
Telephone: (886-2) 321-0216
Telefax: (886-2) 394-2621
Telex: 11285 (SENCORP)

UNITED STATES:

Harold C. Lindberg
83-A Hardee Lane
Whispering Pines, North Carolina 28327
Telephone: (919) 949-3622
Telefax: (919) 949-2626

Ralph O. Smith
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 272-6246
Telefax: (203) 271-1346

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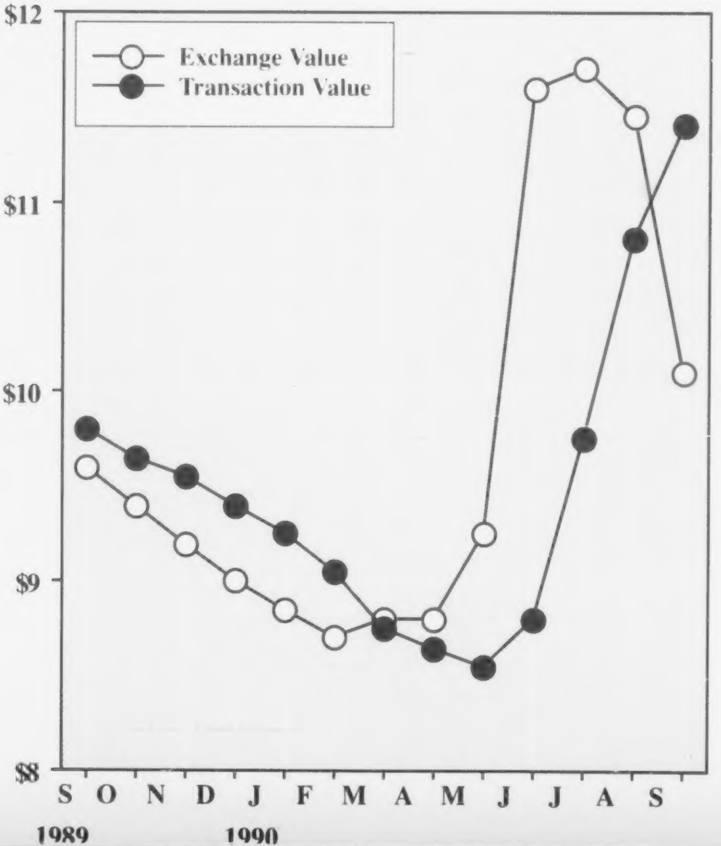
Monthly Report

October 1990 Number 266

Consolidation of German Electric Utilities 13
Major Uranium Suppliers of the 1990s 26
Natural Uranium Supply: 1990–2005 34



NUEXCO

INTERNATIONAL HEADQUARTERS

Oren L. Benton – Chairman and Chief Executive Officer
Earl E. Hoellen – President and Chief Operating Officer

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202 USA

Telephone: (303) 899-4500
Telefax: (303) 899-4555
Telex: 450202 (NUEXCO)

SERVICE LOCATIONS

DENVER, COLORADO, USA

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202
Telephone: (303) 899-4500
Telefax: (303) 899-4555
Telex: 450202 (NUEXCO)

SAN FRANCISCO, CALIFORNIA, USA

Building 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telefax: (415) 854-2115
Telex: 470674 (NUEXCO SF)

WASHINGTON, D.C., USA

11 Dupont Circle, Suite 505
Washington, D.C. 20036
Telephone: (202) 328-9250
Telefax: (202) 328-6699
Telex: 451691 (NUEXCO DC)

HONG KONG

1403 Shui On Centre
6-8 Harbour Road, Wanchai
Hong Kong
Telephone: (852) 865-1418
Telefax: (852) 865-2721
Telex: 67206 (CNITC)

ZURICH, SWITZERLAND

Leberngasse 15
4603 Olten
Switzerland
Telephone: (41-62) 320032
Telefax: (41-62) 321450
Telex: 981600 (NUXCH)

GENEVA, SWITZERLAND

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telefax: (33-50) 428526
Telex: 385288 (NUEXCO F)

SERVICE ENTITIES

NUEXCO Trading Corporation	Earl E. Hoellen, President
NUEXCO Information Services Company	Earl E. Hoellen, President
NUEXCO Transportation & Services Company ("NuTranS")	Robert L. Bovey, President
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Managing Editor:
R. Wesley Miller

Director-Market Analysis:
Treva E. Klingbiel

Editor:
France Addington-Lee

Assistant Editor:
Kenten D. Lindberg

Editorial Assistant:
Alan L. Wolcott

Supply Analysis:
Thomas C. Pool

Demand Analysis:
John M. Vallance

Market Analysis:
David S. Schramm

Research Services:
Carolyn B. McCants

Subscription Services:
Lori A. Mattics

Washington Focus:
Linda L. Gunter

Published by:
NUEXCO
Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202
Telephone: (303) 899-4500
Telefax: (303) 899-4555
Telex: (303) 450202 (NUEXCO)

Other NUEXCO Publications:
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TABLE OF CONTENTS

Market Review 1
- Market Values Summary
- September Market Review
- Current Market Data

Recent Developments 13
- Consolidation of German Electric Utilities
- Rosita Project Begins Operation
- NPT Review Conference
- Uranium Institute Conference
- USCEA Conference
- Washington Focus
- Industry Briefs

Speech 26
- **The Major Uranium Suppliers of the 1990s**

A speech by Treva Klingbiel, vice-president of NUEXCO Information Services, discusses how three major producers, Cameco, Cogema, and RTZ, have weathered the industry's current consolidation phase and will become the major suppliers of the 1990s.

Analysis and Commentary 34
- **Natural Uranium Supply: 1990–2005**

NUEXCO projects cumulative uranium production will total two billion pounds equivalent U_3O_8 during the period 1990–2005. Given current production capability and inventory levels, the supply of uranium will be more than adequate to meet expected uranium demand.

Nuclear Industry Calendar 38

Historical Market Data 39

Government Statistics 45

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NUEXCO

October 1990
No. 266

MARKET REVIEW

Market Values Summary

NUEXCO Market Values	This Report September 30, 1990	Last Report August 31, 1990	12 Months Ago September 30, 1989
EXCHANGE VALUE [1]	**\$10.10**/lb equivalent U_3O_8	\$11.45	\$9.60
UF_6 VALUE [2]	**\$29.50**/kg U as UF_6	\$32.25	\$29.75
LOAN RATE [3]	**3.5%**/annum	3.5%	3.5%
CONVERSION VALUE [4]	**\$1.45**/lb U as UF_6	\$1.45	\$1.90
SWU VALUE [5] **(0.3 w/o tails assay)**	**\$50**/SWU	\$50	\$63
TRANSACTION VALUE [6]	**\$11.40**/lb equivalent U_3O_8	\$10.80	\$9.80
Transactions	**15**	27	19
Months	**3**	3	4
Millions of Pounds	**3.7**	5.5	2.7

DEFINITIONS

[1] The **Exchange Value** is NUEXCO's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.

[2] The **UF_6 Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.

[3] The **Loan Rate** is NUEXCO's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.

[4] The **Conversion Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.

[5] The **SWU Value** is NUEXCO's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.

[6] The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:

a) Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;
b) At least ten transactions;
c) Transactions involving a sum total of at least 2 million pounds equivalent U_3O_8.

DERIVATIONS AND COMMENTS

- All **Market Values** are expressed in terms of US\$.
- All **Market Values** are based on:
  - Data from recently completed transactions.
  - Data from pending transactions.
  - Firm bids to buy or borrow, and firm offers to sell or lend.
  - Prices purchasers or rates borrowers have expressed a willingness to pay, but for which NUEXCO is not aware of firm bids to buy or borrow and prices sellers or rates lenders have expressed a willingness to accept, but for which NUEXCO is not aware of firm offers to sell or lend.
- Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these **Market Values**.
- In the determination of prices, NUEXCO does not consider charges for transportation other than that customarily provided by suppliers.
- The prices of services or materials delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.
- For the **SWU Value**, NUEXCO converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U^{235} and a product assay of 3.0 weight-percent U^{235}, assuming feed costs corresponding to the NUEXCO **Exchange Value** and **Conversion Value** determined as of the same date.
- In calculating the **Transaction Value**, NUEXCO does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future **Exchange Values** or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it can not currently be determined.
- The sample time for the **Transaction Value** is extended as necessary to satisfy the minima for the number of transactions and quantity of material. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

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SEPTEMBER MARKET REVIEW

(as of September 30, 1990)

OVERVIEW

Supplies were abundant in September, demand for near-term purchases was limited, and sellers competed aggressively. As a result, both the Exchange Value and UF_6 Value declined sharply, showing the largest percentage drops in more than five years. The Exchange Value decreased from $11.45 to $10.10 per pound U_3O_8, while the UF_6 Value dropped from $32.25 to $29.50 per kgU as UF_6.

Six uranium sales totalling over 4.5 million pounds equivalent U_3O_8 are reported. Two long-term concentrates sales totalled 3.8 million pounds. Two near-term sales included 500 thousand pounds as concentrates, and two sales involved enriched uranium product (EUP) containing about 300 thousand pounds equivalent U_3O_8. No natural UF_6 sales are reported.

No loans or conversion sales are reported. The Conversion Value and Loan Rate remained at $1.45 per pound U as UF_6 and 3.5 percent, respectively. The SWU Value also remains unchanged, at $50 per SWU. Three enrichment sales totalled 70 thousand SWU, almost all as EUP.

NATURAL URANIUM AND CONVERSION

The September 30 **Exchange Value** fell nearly 12 percent, to **$10.10** per pound U_3O_8. This $1.35 decline is the largest drop in the Exchange Value since October 31, 1984. It is also the second largest percentage drop in the history of the Exchange Value, exceeded only by the 15% drop on February 29, 1984. Increased buyer and seller awareness of the oversupply of uranium, coupled with low demand, set the stage for aggressive pricing by sellers. Offered prices decreased throughout September and the price decline accelerated during the final week of the month. Two producers purchased a total of 500 thousand pounds equivalent U_3O_8 as concentrates for 1990 delivery. The prices in these two mid-September sales fell several percentage points below the August 31 Exchange Value. Offered prices declined further during the rest of September, so on September 30, the Exchange Value fell even lower than the prices of the mid-month sales. Additionally, one purchase of 500 thousand pounds of concentrates that occurred earlier this year is listed among the recent transactions on page 5. It is excluded from the September 1990 data in **Table 1**, but has been added to the year-to-date figures.

Table 1
NEAR-TERM URANIUM SALES SUMMARY

	September 1990		Year-to-Date	
	No. of Sales	Volume[1]	No. of Sales	Volume[1]
Concentrates	2	0.5	50	20.1
Natural UF_6	0	0.0	27	9.5
EUP	2	0.3	11	4.5
Total	4	0.8	88	34.1

[1] Million Pounds Equivalent U_3O_8

Two long-term natural uranium sales are reported. Utilities purchased 3.8 million pounds of concentrates from producers. One contract uses base-price escalated terms for delivery during 1991-2000. The other contract calls for delivery during the period 1992-1997 with a market-related pricing structure.

* * *

The **UF_6 Value** dropped 8.5 percent, to **$29.50** per kgU as UF_6. This $2.75 decline is the UF_6 Value's largest (both percentage and absolute) since its initial publication on April 30, 1985. Although no natural UF_6 transactions are reported, by the end of the month suppliers were indicating a willingness to sell at or near the September 30 UF_6 Value.

In both the concentrates and natural UF_6 markets, strong seller competition in an environment of abundant supply and low demand led to the price decreases. Demand is particularly low for two reasons.

- Many discretionary buyers purchased material earlier in the year, as prices began to rise, in an attempt to catch the bottom of the market;
- Little firm demand exists, and the few remaining discretionary buyers, seeing offered prices falling steadily, are waiting to make purchases.

As a result, sellers are likely to pursue each opportunity aggressively in the fourth quarter.

Compared to the sum of the values of its components—concentrates and conversion—the UF_6 Value is now more

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Table 2
NEAR-TERM SUPPLY/DEMAND SUMMARY

	Active Supply [1]	Active Demand [1]
• Natural Uranium [2] (thousand lbs equivalent U_3O_8)	5,260	750
• Supply/Demand Ratio:	7.0	
• Loan (thousand lbs equivalent U_3O_8)	8,745	0
• Conversion (thousand lbs U as UF_6)	0	1,060
• SWU (thousand SWUs)	435	225

[1] Supply and demand tables in the current market data section of this Report provide details for each category.
[2] Includes concentrates and hexafluoride.

in balance than at any time in the past year. UF_6 is now selling at a discount of less than one percent compared to its components. Earlier in the year, an abundance of UF_6 relative to concentrates existed and this led to discounts of nearly two dollars per kgU. Now, with the supply of both concentrates and UF_6 more in balance, the discount on UF_6 compared to its component values has diminished significantly.

* * *

The **Transaction Value** rose $0.60, to **$11.40** per pound U_3O_8 based on 15 transactions over 3 months involving 3.7 million pounds equivalent U_3O_8. The current Transaction Value reflects the higher prices of recent months. By averaging qualifying transactions over three months, the calculation smooths rapid market fluctuations.

* * *

Active uranium supply eased slightly, to **5.3** million pounds equivalent U_3O_8. **Active uranium demand** declined to **750** thousand pounds equivalent U_3O_8, resulting in a **supply/demand ratio** of **7.0**. The recent Uranium Institute and US Council for Energy Awareness conferences enhanced recognition of the market's enormous inventory overhang. Although only moderate amounts are actively available for sale, much larger amounts, from any of several national stockpiles, could be moved into the market on short notice. Thus, many buyers and sellers expect this oversupply to continue.

* * *

The **Loan Rate** remains at **3.5** percent per annum. No loans are reported. Loan supply increased to 8.7 million pounds equivalent U_3O_8 (**Table 2**), while demand for loans remained at zero.

* * *

The **Conversion Value** remains at **$1.45** per pound U as UF_6. No conversion transactions are reported, although one European utility is evaluating offers for nearly 500 thousand pounds of conversion services. Ample natural uranium is available, both in the form of concentrates and UF_6. Supply of conversion may appear low, but more than enough UF_6 is available to meet demand, by means of deconversion transactions.

ENRICHMENT SERVICES AND ENRICHED URANIUM PRODUCT

The September 30 **SWU Value** is unchanged at **$50** per SWU. Three secondary market sales involved 70 thousand SWU. In one, a US utility purchased a small quantity of SWU for delivery later this year. The other two sales involved EUP; intermediaries sold material containing over 100 thousand kgU as natural UF_6 and over 50 thousand SWU to a fabricator and a utility.

The US Government's FY1991 began on October 1, 1990. This date marks the end of the Incentive Price (IP1) contracts, and the start of IP2 contracts. The updated IP2 price estimate is $100.60 and is shown in **Table 3**.

Enrichment Lead Times and Fabricator Flexibility

Flexibility of fabricators to meet special customer needs has become a key factor in the secondary enrichment market. For example, SWU buyers occasionally need to give sellers less than the 180-day lead time that was once the industry standard. In past years, the buyer would have been at the mercy of the enricher, without whose cooperation such a request could only have been filled by coincidence; that is, if an inventory holder happened to have on hand enough material at the desired assay and was willing to sell or loan the material on short notice.

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However, their enhanced flexibility now allows fabricators to offer buyers more possibilities for satisfying special needs. Total lead time for the secondary enrichment market is defined by the interval between the time the buyer orders its desired quantity and assays and the time that fabricated fuel is delivered to the reactor site. If a short lead time is needed, the fabricator's flexibility to reduce its turnaround time becomes vital. Three factors have combined in recent years to enhance that flexibility.

- Most fabricators have developed enrichment blending capabilities.
- Fabricators have accumulated large and varied inventories of EUP and have used innovative inventory management techniques to better control their enriched uranium stockpiles.
- Over time, fabricators' customers have come to accept the fungibility of enriched uranium.

At first, fabricators took the initiative, asking some customers to deliver enriched UF_6 with assays different from those specified in their contracts. For instance, instead of providing UF_6 enriched to 3.5 w/o and 3.8 w/o as specified in the design for its reload, the utility would be asked to provide an equivalent amount of material enriched to 4.0 w/o. The delivered material would contain the same number of SWU as the contracted material. However, because the delivered material's natural uranium content would differ from the contracted amount, an adjustment would be made. Such adjustments could be made with cash, but typically involve material. In the example, the utility would have delivered natural UF_6 sufficient to compensate for the reduced natural uranium component of the 4.0 w/o material. The fabricator might then use its working inventory, together with UO_2 blending, to make the utility's fuel and apply the material delivered by the utility to another project. Now, utilities are taking the initiative, asking fabricators if they will accept a different assay, or if the fabricator can meet a shorter lead time if the utility pays a premium. In such an event, the utility would receive its fabricated material on schedule, but actually deliver an equivalent amount of enriched UF_6 at a later date than normal.

The primary enrichers are also reducing lead times. For example, DOE has offered its customers 120–day lead times for standard assays, and 150–day lead times for non-standard assays.

These developments in the primary market will lead to more frequent requests for shorter lead times in secondary enrichment transactions. Even so, purchases with short lead times can still be expected to command prices above prevailing levels, because they represent departures from standard practice. ■

Table 3
ENRICHMENT PRICES
(September 30, 1990)

Prices	This Month Report 266	Last Month Report 265	12 Months Ago Report 254
NUEXCO SWU Value ($US per SWU)	50	50	63
US DOE SWU prices: ($US per SWU)			
USEC	117.85[1]	117.85[1]	117.00[2]
AFC	153.00[3]	153.00[3]	153.00[3]
Requirements	157.00[3]	157.00[3]	157.00[3]
Incentive Price (IP2)[4]	100.60[4]	90.00[5]	90.00[5]
Calculated worth of enriched UF_6[6]: ($US per KgU as UF_6)			
2.0 w/o U_{235}	207	222	228
2.5 w/o U_{235}	285	304	317
3.0 w/o U_{235}	366	389	408
3.5 w/o U_{235}	447	475	501
4.0 w/o U_{235}	530	562	596
4.5 w/o U_{235}	614	650	692

[1] Effective 10/1/89 to 9/30/91.
[2] Effective 10/1/87 to 9/30/89.
[3] Effective since 10/1/84.
[4] IP2: Effective 10/1/90 to 9/30/91, for up to 30% of annual requirements.
[5] Uses Incentive Price IP1 – effective 10/1/86 to 9/30/90, for up to 30% of annual requirements.
[6] Calculated using the NUEXCO Exchange Value, Conversion Value, SWU Value and 0.30 w/o tails assay.

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RECENT TRANSACTIONS

Uranium Sales[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds equivalent U_3O_8)	Price Within Percentage Range[2] of Current Exchange or UF_6 Value	Buyer	Seller	Remarks
4945	1992-1997	1,001-3,000	See Remarks	Utility	Producer	Market Related Pricing
4946	1991-2000	1,001-3,000	See Remarks	Utility	Producer	Base Price Escalated
4947	1990	301-600	**R**	Producer	Producer	Occurred Earlier in 1990
4948	1990	101-300	103-110	Producer	Intermediary	
4951	1990	101-300	103-110	Producer	Intermediary	
4953A	1991	101-300	**R**	Utility	Intermediary	Contained in EUP
4955A	1991	Less than 50	**R**	Fabricator	Intermediary	Contained in EUP

R means that NUEXCO either does not know, or that NUEXCO has restricted that information to protect client or source confidentiality.

[1] Transactions listed are not limited to those in which NUEXCO was involved, but also include others of which NUEXCO is aware. NUEXCO may delay reporting some transactions in order to protect proprietary information.

[2] The ranges *Below 90, 90-97, 98-102, 103-110, Above 110*, represent percentages (rounded to whole numbers) of the appropriate current Exchange Value or UF_6 Value. The endpoints of each range are included within that range.

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RECENT TRANSACTIONS

Natural Uranium Loans[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds equivalent U_3O_8)	Price Within Percentage Range[2] of Current Loan Rate	Borrower	Lender	Remarks

No loans are reported.

Conversion Sales[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity (thousand pounds of U equivalent)	Price Within Percentage Range[2] of Current Conversion Value	Buyer	Seller	Remarks

No conversion transactions are reported.

Enrichment Sales[1]

NUEXCO Transaction Number	Delivery Period	Approximate Quantity[3] (thousand SWU)	Price Within Percentage Range[2] of Current SWU Value[4]	Buyer	Seller	Remarks
4950	1990	Less than 50	98-102	Utility	Intermediary	
4953B	1991	50-100	**R**	Utility	Intermediary	Contained in EUP
4955B	1990	Less than 50	**R**	Fabricator	Intermediary	Contained in EUP

R means that NUEXCO either does not know, or that NUEXCO has restricted that information to protect client or source confidentiality.

[1] Transactions listed are not limited to those in which NUEXCO was involved, but also include others of which NUEXCO is aware. NUEXCO may delay reporting some transactions in order to protect proprietary information.

[2] The ranges *Below 90, 90-97, 98-102, 103-110, Above 110*, represent percentages (rounded to whole numbers) of the appropriate current Market Value. The endpoints of each range are included within that range.

[3] If tails assay is unknown or unspecified, NUEXCO's calculation of SWU quantity assumes 0.30 w/o tails assay.

[4] Prices are usually normalized to 0.30 w/o tails assay. When prices and SWU values are expressed as discounts from a reference price (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage price range is based on the discounted prices, not on the reference price.

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SUPPLY AND DEMAND

Uranium Supply

NUEXCO Project Number	Quantity (Thousand Pounds equivalent U_3O_8) Spot or Near-term[1]	Intermediate or Long-term[2]	Delivery Period	Remarks
Available for Sale:				
ACTIVE				
89-1001	1,305	—	1991	UF_6
90-1078A	2,175	2,175 per year	1991-1993	UF_{6e}
90-1208*	280	—	1990	UF_6
90-1227*	500	—	1990	
90-7001	1,000	1,000 per year	1991-1995	
Total	**5,260**			
INACTIVE	**2,850**			
Available for Loan:				
ACTIVE				
88-1182	4,000	—	—	U_3O_8/UF_6
90-1016	300	—	—	U_3O_8
90-1033	1,270	—	—	UF_6
90-1108	1,000	—	—	U_3O_8
90-1110	250	—	—	U_3O_8
90-1180	525	—	—	U_3O_8
90-1212*	400	—	—	U_3O_8
90-1230*	1,000	—	—	U_3O_8
Total	**8,745**			
INACTIVE	**1,390**			

*New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes material deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Active Projects reclassified as Inactive since last month: *none*
Active Projects removed since last month: 90-1183

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SUPPLY AND DEMAND

Uranium Demand

NUEXCO Project Number	Quantity (Thousand Pounds equivalent U_3O_8) Spot or Near-term[1]	Quantity (Thousand Pounds equivalent U_3O_8) Intermediate or Long-term[2]	Delivery Period	Remarks
Inquiries to Purchase:				
ACTIVE				
90-1100A	45	—	1991	UF_{6e}
90-1182	25	—	1991	
90-1207*	100	—	1990	U_3O_8/UF_6
90-1209*	280	—	1991	UF_6
90-1210*	100	—	1990	U_3O_8/UF_6
90-1229*	200	—	1991	
90-1098	—	250 per year	1992-1994	
90-1155	—	325 per year	1991-1995	
90-1170	—	290	1992-1996	
90-1205*	—	260 per year	1992-2001	UF_6
90-1206*	—	390 per year	1993-2001	UF_6
90-1215*	—	260 per year	1993-1997	U_3O_8/UF_6
Total	**750**			
INACTIVE	**2,080**			
Inquiries to Borrow:	*No inquiries to borrow are reported.*			

* New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes material deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Active Projects removed since last month: 90-1177A, 90-1199.

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SUPPLY AND DEMAND

Conversion Supply And Demand

NUEXCO Project Number	Quantity (Thousand Pounds U as UF_6) Within 3 Years[1]	Quantity (Thousand Pounds U as UF_6) Beyond 3 Years[1]	Remarks
Available for Sale:	*No offers to sell are reported.*		
Inquiries to Purchase:			
ACTIVE			
90-1184	400		
90-1214*	660		
Total	**1,060**		
INACTIVE	*None reported.*		

* New or revised since last month.

[1] Measured from the date of this Report.

Projects removed since last month: *none*

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SUPPLY AND DEMAND

SWU Supply And Demand

NUEXCO Project Number	Quantity (Thousand SWUs) Spot or Near-term[1]	Quantity (Thousand SWUs) Intermediate or Long-term[2]	Delivery Period	Remarks
Available for Sale:				
ACTIVE				
90-1078B	435	435 per year	1991-1993	UF6e
90-7000	—	1,000	1991 on	
Total	**435**			
INACTIVE	*None reported.*			
Inquiries to Purchase:				
ACTIVE				
90-1100B	15	—	1991	UF6e
90-1224*	60	100 per year	1992-1994	
90-1225*	150	—	1991	
88-1061	—	500	1991-1995	
90-1076	—	350 per year	1992-1998	
90-1094	—	500	1992-2000	
90-1144	—	60 per year	1992-2001	
90-1181	—	600	1996-2003	UF6e
90-1196	—	60 per year	1995 on	
Total	**225**			
INACTIVE	**1,545**			

* New or revised since last month.

[1] For delivery within one year, measured from the date of this Report. This category excludes SWU deliverable within one year under other than spot or near-term contracts.

[2] For delivery beyond one year, measured from the date of this Report.

Active Projects removed since last month: 90-1177B

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MARKET VALUES EXPRESSED IN SELECTED CURRENCIES

Exchange Value[1]

Country (currency)	per lb equivalent U_3O_8 as Concentrates			per kg U as Concentrates		
	This Month (Sept. 30, 1990)	Last Month (Aug. 31, 1990)	12 Months Ago (Sept. 30, 1989)	This Month (Sept. 30, 1990)	Last Month (Aug. 31, 1990)	12 Months Ago (Sept. 30, 1989)
Australia (dollar)	12.22	13.98	12.42	31.77	36.35	32.30
Belgium (franc)	324.55	368.29	379.30	843.76	957.46	986.09
Canada (dollar)	11.67	13.13	11.33	30.33	34.14	29.47
EEC (ecu)	7.69	8.68	8.77	19.99	22.56	22.80
Finland (markka)	37.37	42.22	41.27	97.15	109.77	107.30
France (franc)	52.73	60.12	61.22	137.09	156.29	159.17
Italy (lira)	11,796	13,294	13,149	30,668	34,561	34,184
Japan (yen)	1,393	1,652	1,347	3,622	4,294	3,503
Netherlands (guilder)	17.77	20.21	20.39	46.20	52.54	53.00
So. Africa (comm. rand)	25.96	29.32	26.27	67.50	76.23	68.28
Spain (peseta)	986.81	1,118	1,155	2,565	2,907	3,004
Sweden (krona)	58.01	65.96	61.98	150.82	171.47	161.12
Switzerland (franc)	13.06	14.83	15.65	33.96	38.56	40.69
UK (pound)	5.37	5.97	5.96	13.97	15.52	15.48
US (dollar)	10.10	11.45	9.60	26.26	29.77	24.96
West Germany (mark)	15.77	17.94	18.06	40.99	46.63	46.95

Transaction Value[1]

Country (currency)	per lb equivalent U_3O_8 as Concentrates			per kg U as Concentrates		
	This Month (Sept. 30, 1990)	Last Month (Aug. 31, 1990)	12 Months Ago (Sept. 30, 1989)	This Month (Sept. 30, 1990)	Last Month (Aug. 31, 1990)	12 Months Ago (Sept. 30, 1989)
Australia (dollar)	13.79	13.19	12.68	35.86	34.28	32.97
Belgium (franc)	366.32	347.38	387.20	952.36	903.11	1,007
Canada (dollar)	13.17	12.39	11.57	34.23	32.21	30.08
EEC (ecu)	8.68	8.18	8.95	22.56	21.28	23.28
Finland (markka)	42.18	39.82	42.13	109.66	103.53	109.53
France (franc)	59.52	56.70	62.50	154.74	147.42	162.49
Italy (lira)	13,315	12,539	13,423	34,615	32,599	34,896
Japan (yen)	1,573	1,558	1,375	4,088	4,050	3,576
Netherlands (guilder)	20.06	19.06	20.81	52.15	49.55	54.10
So. Africa (comm. rand)	29.31	27.66	26.81	76.19	71.90	69.71
Spain (peseta)	1,114	1,055	1,179	2,896	2,742	3,066
Sweden (krona)	65.48	62.21	63.27	170.23	161.74	164.48
Switzerland (franc)	14.75	13.99	15.98	38.34	36.37	41.54
UK (pound)	6.06	5.63	6.08	15.77	14.64	15.81
US (dollar)	11.40	10.80	9.80	29.64	28.08	25.48
West Germany (mark)	17.80	16.92	18.43	46.27	43.98	47.93

[1] Calculated using currency exchange rates published in *The Wall Street Journal* on the last working day of the month.

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MARKET VALUES EXPRESSED IN SELECTED CURRENCIES

Conversion Value[1]

Country (currency)	per lb U as UF_6 This Month (Sept. 30, 1990)	Last Month (Aug. 31, 1990)	12 Months Ago (Sept. 30, 1989)	per kg U as UF_6 This Month (Sept. 30, 1990)	Last Month (Aug. 31, 1990)	12 Months Ago (Sept. 30, 1989)
Australia (dollar)	1.75	1.77	2.46	3.87	3.90	5.42
Belgium (franc)	46.49	46.64	75.07	102.72	102.82	165.50
Canada (dollar)	1.67	1.66	2.24	3.69	3.67	4.95
EEC (ecu)	1.10	1.10	1.74	2.43	2.42	3.83
Finland (markka)	5.37	5.35	8.17	11.83	11.79	18.01
France (franc)	7.57	7.61	12.12	16.69	16.78	26.71
Italy (lira)	1,694	1,684	2,602	3,734	3,711	5,737
Japan (yen)	200.03	209.17	266.67	440.99	461.15	587.90
Netherlands (guilder)	2.55	2.56	4.03	5.63	5.64	8.89
So. Africa (comm. rand)	3.73	3.71	5.20	8.22	8.19	11.46
Spain (peseta)	141.67	141.59	228.67	312.33	312.15	504.13
Sweden (krona)	8.33	8.35	12.27	18.36	18.41	27.04
Switzerland (franc)	1.88	1.88	3.10	4.13	4.14	6.83
UK (pound)	0.77	0.76	1.18	1.70	1.67	2.60
US (dollar)	1.45	1.45	1.90	3.20	3.20	4.19
West Germany (mark)	2.26	2.27	3.57	4.99	5.01	7.88

SWU Value And UF_6 Value[1]

Country (currency)	SWU Value at 0.30 w/o Tails Assay This Month (Sept. 30, 1990)	Last Month (Aug. 31, 1990)	12 Months Ago (Sept. 30, 1989)	UF_6 Value per kg U as UF_6 This Month (Sept. 30, 1990)	Last Month (Aug. 31, 1990)	12 Months Ago (Sept. 30, 1989)
Australia (dollar)	60.50	61.05	81.53	35.69	39.38	38.50
Belgium (franc)	1,607	1,608	2,489	947.94	1,037	1,175
Canada (dollar)	57.75	57.35	74.38	34.07	36.99	35.12
EEC (ecu)	38.06	37.89	57.55	22.45	24.44	27.17
Finland (markka)	185.00	184.37	270.85	109.15	118.92	127.90
France (franc)	261.06	262.52	401.79	154.02	169.33	189.73
Italy (lira)	58,398	58,052	86,290	34,455	37,443	40,748
Japan (yen)	6,898	7,213	8,842	4,070	4,652	4,175
Netherlands (guilder)	87.98	88.25	133.78	51.91	56.92	63.17
So. Africa (comm. rand)	128.53	128.04	172.37	75.84	82.59	81.39
Spain (peseta)	4,885	4,882	7,582	2,882	3,149	3,580
Sweden (krona)	287.19	288.02	406.71	169.44	185.77	192.05
Switzerland (franc)	64.67	64.78	102.72	38.16	41.78	48.50
UK (pound)	26.60	26.07	39.08	15.69	16.81	18.45
US (dollar)	50.00	50.00	63.00	29.50	32.25	29.75
West Germany (mark)	78.05	78.32	118.51	46.05	50.52	55.96

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[1] Calculated using currency exchange rates published in *The Wall Street Journal* on the last working day of the month.

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RECENT DEVELOPMENTS

Germany

Consolidation of German Electric Utilities

On October 3, 1990, Germany officially became one country again, after 45 years of division. One of the many steps toward this unification was the consolidation of systems for the generation and distribution of electricity. On August 22, West Germany's electric utilities signed a contract with the East German government establishing the basic plan for restructuring East Germany's electricity supply industry. The three largest electric utilities in West Germany will acquire a majority interest in most of East Germany's electricity production and distribution, both at the high-voltage, national grid level and at the low-voltage, regional distribution level.

Before the contract was signed, three national companies supplied power to East Germany's regional electricity distributors.

- *Vereinigte Kraftwerks AG Peitz* (**VKP**) was responsible for conventionally-produced electricity, 85 percent of which was produced from brown coal.
- *VE Kombinat Kernkraftwerke* (**KKW**) operated all nuclear power plants.
- *Verbundnetz AG* (**VERB**) handled the national distribution of electricity.

West Germany's three largest electric utilities, Bayernwerk AG, Preussenelektra AG, and RWE AG, formed a new company named Vereinigte Energiewerke (VEAG) which will operate VKP and VERB in a caretaker role for the remainder of 1990. During this same period, VKP and VERB will be combined into one entity. Starting in 1991, VEAG will acquire a 75-percent interest (the limit imposed by the contract) in that new entity. The East German State Trust Agency responsible for privatization, modernization, or dissolution of East German companies will acquire the remaining 25–percent interest of the new company. Of that 25-percent interest, the Agency will offer 60 percent (15 percent of the total) for sale to other European Community investors.

The East German Trust Agency and RWE, through its wholly-owned subsidiary Rheinbraun AG, have already set up a new company (Lausitzer & Mitteldeutschen Braunkohlen) to handle modernization and privatization of the East German brown coal production centers. Rheinbraun has a 60-percent interest in this new company and the trust agency has a 40-percent interest.

The three West German utilities have agreed to make an immediate investment of DM1.9 billion (US$1.2 billion) in VKP and VERB, for improvements and repair. Karl-Mermann Steinberg, East German Minister of Environment & Nuclear and signatory of the contract for East Germany, estimates that bringing the East German systems up to West German standards will ultimately cost DM40 billion (US$25 billion).

The three West German utilities have chosen not to assume the responsibility for KKW. Therefore, the new federal government will assume responsibility for the East German nuclear power industry.

The contract allows the utilities after 1990 to acquire an interest in the regional electricity distribution areas. East Germany has 15 regional electricity (low-voltage) distribution areas—*East Berlin, Chemnitz, Cottbus, Dresden, Erfurt, Frankfurt (Oder), Gera, Halle, Leipzig, Magdeburg, Neubrandenburg, Potsdam, Rostock, Schwerin, and Suhl.* The contract limits the three West German utilities' total interest in these distribution areas to about 60% of the total East German electrical demand. The three large West German utilities plan to take a 51% interest in 11 of these 15 regional electricity distribution areas. The Trust Agency will hold the remaining 49% interest, which it can then sell to other companies in the European Community. Electricité de France (EdF) has indicated a strong desire to obtain such an interest, and has taken the lead in a consortium of European electricity producers to acquire an interest. In return, Germany expects to be able to acquire an interest in other European electrical industries.

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Each West German utility will set up another new corporation to handle that utility's interests in its given distribution areas. **Figure 1** shows which utilities gained either majority or minority interests, through their new corporations, in particular distribution areas. If two of the West German utilities share the majority interest in a region [such as Erfurt, Frankfurt (Oder), or Chemnitz], they will allocate that 51% among themselves in a separate agreement. The Trust Agency will still control the remaining 49% interest.

Six of West Germany's smaller electric utilities will invest in the other four regional electricity distribution areas. The six utilities are:

- Hamburgische Electrizitaetswerke;
- Energie-Versorgung Schwaben AG;
- Vereinigte Elektrizitaetswerke Westfalen AG;
- Badenwerke AG;
- Isar–Amperwerke AG;
- Berliner Kraft und Licht AG.

Figure 1 also shows these six utilities' percentage interests in the four regional electricity distribution areas.

An earlier bid by the three large utilities for East Germany's electric power industry had prompted the smaller utilities to complain to anti-cartel authorities that the smaller utilities were being closed out of any interest in East Germany. Anti-cartel authorities in both Germanies refused to approve the original bid. When that bid was refused, the smaller West German utilities (except Isar-Amperwerke) submitted their own bid to East Germany's state trust.

The East German trust agency held further negotiations with the three largest utilities, which resulted in a contract with an allowance for other investors, such as smaller West German utilities, or other European/non-German investors. No information is yet available as to whether the contract restricts the current investors from reselling all or part of their interests.

Legend for Figure 1

GDR — German Democratic Republic (Trust Agency)
RWE — RWE AG
Preag — Preussenelektra AG
Bayern — Bayernwerke AG
RBW — Rheinbraun AG
VEAG — Vereinigte Energiewerke AG
L&MB — Lausitzer & Mitteldeutschen Braunkohlen
KKW — VE Kombinat Kernkraftwerke
VERB — Verbundnetz AG
VKP — Vereinigte Kraftwerks AG Peitz
VEW — Vereinigte Electrizitaetswerke Westfalen AG
HEW — Hamburgische ElectrizitaetsWerke
EVS — Energie–Versorgung Schwaben AG
BKL — Berliner Kraft und Licht
Baden — Badenwerke AG
Isar — Isar–Amperwerke AG

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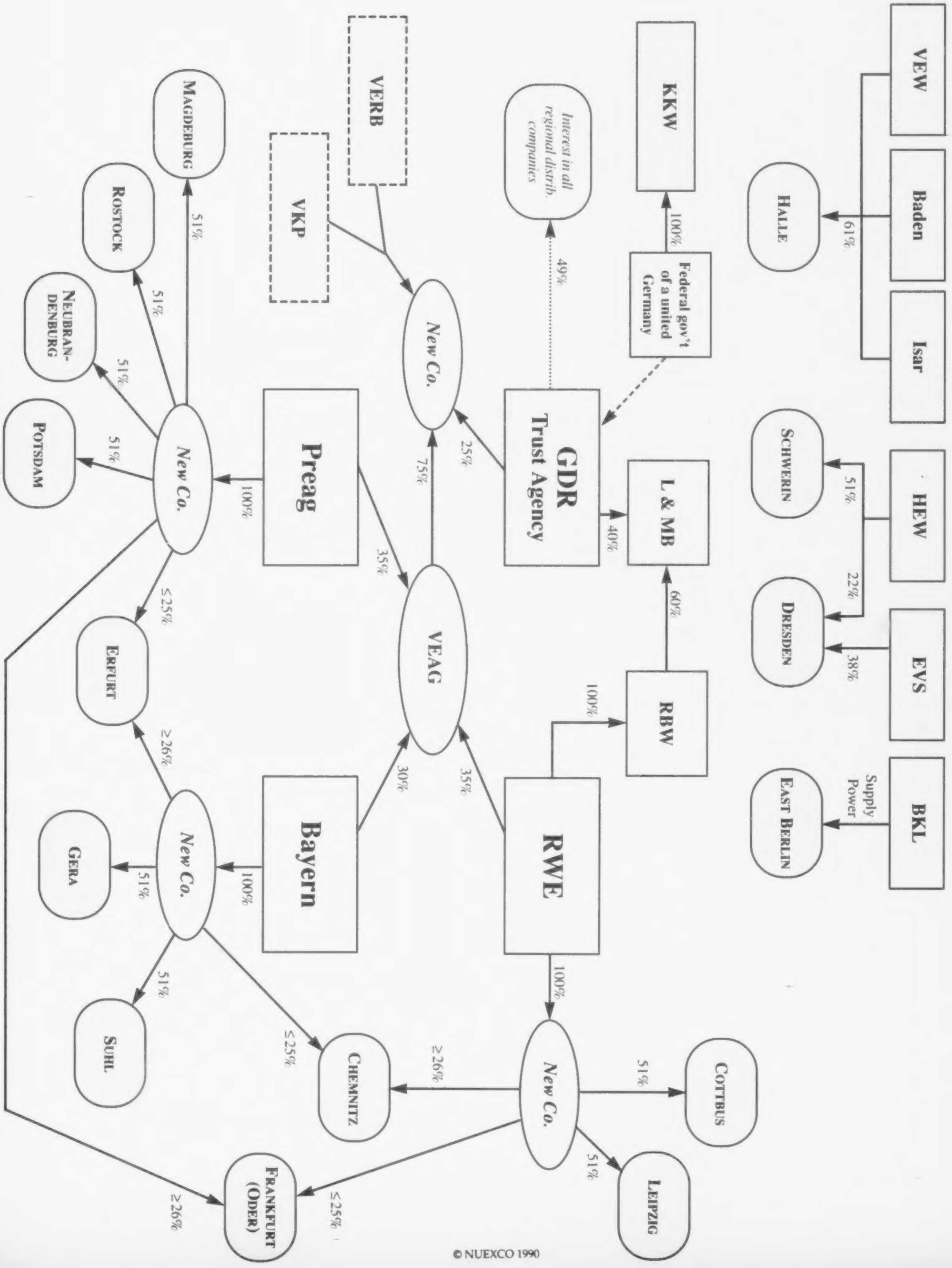
VEW
Baden
Isar
61%
HALLE
HEW
51%
SCHWERIN
22%
DRESDEN
EVS
38%
BKL
Supply Power
EAST BERLIN
KKW
100%
Federal gov't of a united Germany
Interest in all regional distrib. companies
49%
GDR Trust Agency
40%
L & MB
60%
RBW
100%
RWE
100%
New Co.
51%
COTTBUS
51%
LEIPZIG
≥26%
CHEMNITZ
≤25%
FRANKFURT (ODER)
VERB
VKP
New Co.
25%
75%
VEAG
35%
35%
30%
Preag
100%
New Co.
51%
MAGDEBURG
51%
ROSTOCK
51%
NEUBRAN-DENBURG
51%
POTSDAM
≤25%
ERFURT
≥26%
≥26%
Bayern
100%
New Co.
51%
GERA
51%
SUHL
≤25%

Figure 1 — German Electricity Industry Structure

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USA

Rosita Project Initiates Production

Uranium Resources, Inc. (URI) began operating the Rosita solution mine on September 4, 1990. The mine, located 60 miles west of Corpus Christi, Texas in northeastern Duval county, is the latest in a series of in-situ leach production facilities developed by the company.

The Rosita Project (formerly named the Rogers Project) was discovered in the mid-1970s by Union Carbide Corporation (UCC). UCC implemented a comprehensive drilling program at that time. In 1980, Chevron Resources Company (CRC) acquired the leases from UCC for about $5.0 million. During 1980-1981, Chevron drilled more than 2000 rotary holes and 70 core holes in the leasehold area. Through this evaluation and coring program, Chevron's objective was to establish the mineability of the ore. Because the deposit is shallow (less than 250 feet), Chevron considered the Rogers Project as a potential open–pit operation. At that time, CRC calculated total in–place reserves at 3.8 million pounds equivalent U_3O_8.

URI acquired the project leases from the landowners in late 1985. The company purchased the drill data from CRC at the same time. Moreover, URI acquired additional leases adjacent to the initial project. The Rosita property now encompasses more than 3,500 acres. Total project in-place proven reserves amount to 6.2 million pounds equivalent U_3O_8.

URI received all necessary permits and licenses by mid-1989 and commenced process facility construction and well-field planning. Total capital cost for facility development was estimated at $4.0–4.5 million. Rosita will be operated as a semi-independent production facility (2500-2800 gallons per minute). The filter-pressed concentrates will receive final drying at URI's Kingsville Dome Project, located in central Kleberg County, Texas, approximately 70 miles away.

The initial well-field area contains a total of 205 wells (103 production and 102 injection wells) at depths averaging 220 feet. Anticipated average flow rates for the production wells will be 20-25 gallons per minute over the well-field life. The well patterns have been installed in two configurations in order to determine the most efficient layout for future production areas. New wells will be installed at a rate to maintain the annual production rate of 800-900 thousand pounds equivalent U_3O_8 following the initial year's output of an estimated 1.0 million pounds equivalent U_3O_8. Well installation for the second production area is scheduled to begin in November, 1990.

URI intends to conduct necessary restoration on an on-going basis by utilizing reverse osmosis. This concept is a departure from traditional solution mines, where restoration is usually initiated following the cessation of active production.

Dustin Garrow

Figure 1 — Central recovery plant at the Rosita ISL Project in southern Texas.

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NPT Conference

NPT Review Conference Ends Without Consensus

On September 15, the Fourth Review Conference on the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) concluded without a final consensus document agreed to by all of the delegates. The failure of the 142 NPT signatory nations to reach an agreement does not bode well for the 1995 conference. The current treaty expires in 1995, and that final conference must decide whether to extend the treaty (and for how long), modify it, or let it expire and try to create a new treaty more acceptable to all nations.

The conference began on August 20 and was scheduled to run for four weeks. Since the last review conference in 1985 (reviews are held every five years), significant progress had been made in areas covered by the treaty—the fall of the Iron Curtain, the signing of the INF treaty, major progress on a START treaty, and reduced fears regarding the intentions of non-signatory states such as Argentina, Brazil, and South Africa. South Africa has even recently announced that it intends to sign the NPT soon, provided other nations in southern Africa also sign. Additionally, two non-signatory, nuclear weapon states (NWS), France and China, asked and were granted permission to attend the conference as observers. This development, the first time either nation had even attended, was a positive sign for the future of the treaty. So although there were new concerns, such as transfers of ballistic missiles to non-nuclear weapons states (NNWS) and proliferation concerns about countries such as Iraq and North Korea, the conference began optimistically. A successful conference would set an important precedent for the 1995 conference.

Before the conference began, eight key issues needed to be carefully addressed to reach a consensus on a final document.

- Conditions of Nuclear Trading—In the past, this point was frequently discussed, because the non-discriminatory intentions of the NPT often conflicted with the conditions imposed by suppliers of nuclear power technology. Suppliers often want complete safeguards of all nuclear activities related to the material they supplied, yet others oppose too much interference with trade that would limit the access to technology many NNWS states desire.
- Compliance with Articles I and II of the Treaty—Have all NWS and NNWS met their obligations not to transfer nuclear weapons and technology to other countries, and not to develop nuclear weapons? Delegates raised questions about the intentions of Iraq, North Korea, and Israel, and all of the NWS.
- Compliance with Article IV of the Treaty—Have the NWS demonstrated their commitment to nuclear arms reductions? Considerable progress has been made in the past five years on nuclear weapons disarmament agreements. But debate about Test Ban Treaties became the major issue of the conference.
- Additional Security Assurances—NNWS want further assurances that the NWS will not use or threaten to use nuclear weapons against NNWS.
- Changes to the IAEA Safeguards System—The conference needed to discuss how the IAEA safeguards against diversion of nuclear material can continue to operate effectively in an era of zero-growth budgets.
- Nuclear Weapon-Free Zones—Article VII of the NPT permits regional treaties to assure the total absence of nuclear weapons. These treaties often raise questions of the geographical status of the zone and whether peaceful nuclear explosion testing is permitted. This issue is always controversial and potentially divisive.
- Assurances against Attacks on Nuclear Plants—This issue is most troublesome within the Middle East; each side accuses the other of attacks or plans of attack. Without guarantees against attack, states would be reluctant to invest in costly nuclear energy projects, thereby inhibiting the growth of nuclear power.
- The 1995 Extension Conference—The NPT does not outline how long to extend the treaty, only that a meeting to decide this issue is to be convened for such a purpose after 25 years. The 1990 conference was important to set the stage for this meeting.

Most of these key issues were handled effectively during the conference. The main issue that ended up causing difficulties was the issue on compliance with Article IV—Nuclear Arms Reductions. This issue was not expected to

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be so complex. Recent progress on START negotiations, the signing of the INF Treaty, and the fall of the Iron Curtain were viewed by many as a solid demonstration of progress on nuclear arms reduction.

However, a small group of nations, led by Mexico, insisted on a comprehensive test ban treaty (CTBT) prohibiting all testing of nuclear weapons worldwide. The overwhelming majority of the NPT signatories were satisfied with progress on Article IV and did not feel a CTBT was worth risking the entire success of the conference. Extensive negotiations and proposals began with two weeks remaining at the conference. By the final week, the CTBT issue had emerged as the key element blocking a consensus Final Document. In the final two days, the nations of Syria, the Phillippines, Venezuela, Sri Lanka, and Uganda, which originally supported the CTBT issue, had agreed to a compromise. But by the end of the conference, Mexico, Indonesia, and Iran still insisted that nuclear arms control would not be possible without a CTBT. Even after last-ditch compromise language was proposed in order to develop a Final Document, Mexico still refused to consent and the conference ended unsuccessfully.

Conclusion

Regretfully, the lack of a consensus Final Document prevents progress made in other areas from being enacted. By the end of the conference, Belgium, Switzerland, Italy, Great Britain, and the Soviet Union had all agreed to draft language accepting full-scope safeguards. This would have complemented Germany's recent announcement that it would accept full-scope safeguards.

The lack of a Final Document does not doom the NPT, but does put added pressure on the 1995 conference. That conference will probably be the most important world meeting on nuclear weapons ever held. A majority of the 142 signatory nations must agree to extend the treaty for a certain amount of time. The NPT remains the cornerstone of nuclear non-proliferation and its contribution to global security is unequaled. The Treaty is now 20 years old and must evolve to meet changing world conditions. It will be up to the participants of the 1995 conference to preserve the intentions of the NPT and conclude the tough compromises necessary from all nations. □

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Uranium Institute Symposium '90

Introduction

The Uranium Institute held its Annual Symposium on September 5-7, 1990, in London. As addressed by keynote speaker, Dr. Kunihiko Uematsu, the future of nuclear energy was the primary theme of the conference. The growing realization of the need for more energy, and concerns about the environment, make nuclear power an alternative that must be seriously considered. The Symposium looked at many facets of the fuel cycle, from supply and demand to reprocessing. Overviews of selected papers are presented in the following paragraphs.

Mr. Gerald Grandey, President of Energy Fuels and Chairman of the UI Committee on Supply, Demand, and Trade presented an update of the committee's uranium forecast through the year 2005. Reactor requirements are expected to grow slightly, rising to about 52,000 MTU per year by the year 2000 and remain steady thereafter. Production is forecast to be near 43,000 MTU per year. Any shortfall will be made up from existing inventories. With inventory drawdowns existing and expected production, new supplies from the Soviet Union and China, and reprocessing, the committee projects that a uranium shortfall is unlikely to develop during the 1990's.

Mr. Doug Underhill, Manager of the Mineral Resources Division of the Nuclear Assurance Corporation (NAC), spoke of uranium exploration programs and their outlook for the 1990's. He described how exploration efforts are directly correlated to the spot market price. As the price dropped during the 1980's, after all-time high levels in the late 1970's, exploration dropped as well. Exploration expenditures by WOCA countries are at only 15% of their 1979 peak levels. Companies have compensated by acquiring new resources, not discovering them. NAC believes if spot market prices remain low through the mid-1990's, and consequently, if exploration expenditures also remain low, the delay in discovering new reserves could prove troublesome by the turn of the century.

Ms. Heera Clark, Vice-President of Marketing and Consulting at the Uranium Exchange Company, discussed uranium procurement practices of US and non-US utilities. US utilities have been put under pressure from ratepayers, government officials, shareholders, and Public Utility Commissions to keep costs down. This pressure, when combined with the abundance of supply, led many US utilities to purchase their uranium requirements on the spot market and make security of supply a minor consideration. In contrast, non-US utilities still value and depend upon diverse and secure sources of supply, and are willing to pay premium prices to assure its existence. The result is that some producers are being effectively subsidized by the higher-priced long-term contracts of non-US utilities, and US utilities are benefitting by getting lower prices on the spot market and still being assured of supply. During the 1990's, this situation may change slightly, with each side approaching the middle. Ms. Clark does not project that the uranium market will become a true commodities market during the 1990's, without regard to assurance of supply, but states that all market participants would be better off in the long run if the uranium market began to more closely follow the laws of actual supply and demand.

Dr. John Gittus, Director-General of the British Nuclear Forum (BNF), spoke first during one of the most interesting sessions of the symposium. He discussed evolving British attitudes toward nuclear power. Using some of the results of the surveys that the BNF (formerly the Nuclear Electricity Information Group) has been taking in the UK since May 1986 (just after Chernobyl regarding nuclear power, Dr. Gittus described how trends of favor or disfavor were directly affected by recent events. A negative announcement (Chernobyl, Sellafield medical effects) resulted in a lower acceptance, as would be expected. While no solid conclusions can yet be drawn regarding nuclear power, the surveys have proven successful enough that they can be used to help the industry improve the acceptability of nuclear power.

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Dr. John Durant, Assistant Director and Head of Research and Information Services at the Science Museum of London, addressed public perception of civil nuclear power. He discussed studies on how people perceive nuclear power and how they perceive science and technology in general. His evidence suggests that the British public recognized the benefits of technology, but are cautious and critical of sciences that they view as immoral or unsafe. Nuclear power is an example of a technology that the public does not understand very well, and consequently, views with caution. The industry must recognize this, and help further the knowledge of the public about nuclear power and, importantly, increase their knowledge of science and technology in general.

Dr. Ann Bisconti, USCEA Vice-President for Research and Program Evaluation, discussed US public opinion in a changing energy environment. Public support of nuclear power in the US is higher than many people realize. In June 1990, 83% of the public felt that nuclear power was important in meeting future US energy needs. Growing environmental concerns and more frequent power shortages in the US, will lead the public to increase their recognition of the need for electricity and the need for clean, reliable, and affordable sources of that electricity.

Mr. Eiji Takeuchi, General Manager of the Nuclear Power Operations Department for Chubu Electric Power Company, spoke on gaining public acceptance of nuclear power in Japan. Japan has managed to get public acceptance of nuclear power by unfailing attention to detail, demonstrating operational excellence, and by effectively communicating with the general public and with public interest groups. The Japanese government has also been very supportive. Since the Chernobyl accident, the anti-nuclear movements in Japan have become more active, and have begun appealing to the emotions, not reason, of the public. Mr. Takeuchi stated that the nuclear industry can take the following actions to further public acceptance.

- operate existing plants safely and effectively;
- provide the public with accurate and timely information;
- communicate face-to-face with the public, not just with one-way media tactics;
- address public concerns of safety and waste disposal;
- enhance nuclear safety worldwide.

Dr. Andrei Gagarinski, Deputy Director of the Kurchatov Institute of Atomic Energy in the USSR, discussed the status and prospects of nuclear power in the Soviet Union. The country continues to plan aggressively for the use of nuclear power to solve its energy problems. The Chernobyl accident set back the program significantly. The accident stopped construction at 15 sites and stopped plans on 20 more units. As a result of these delays and other factors, the Soviet Union's fuel supply system will be large enough to support a nuclear program three times as large as it will be at the end of the century. Consequently, the Soviet Union has considerable capability to export nuclear fuel materials, to obtain much-needed hard currency.

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USCEA Conference

USCEA Uranium '90 Conference

The USCEA held its Uranium '90 Conference in San Antonio, Texas on September 16-19, 1990. Over 260 delegates attended and 22 papers were presented. Some of the most animated debate followed Tuesday morning's session. Several speakers put forth a utility perspective of short lead times and low inventory as a part of fuel procurement strategy, because the vast abundance of supply makes security of supply much less of a concern than in the past. Brief summaries of selected speeches are presented below.

Session 2: A Changing Supply Regime

The Australian Government's Uranium Policy

Robert J. Crick, Head of the Uranium and Nuclear Industry Branch of the Australian Department of Primary Industries and Energy, discussed the development of Australia's uranium policy. He addressed the confusion over the "three mines policy" for uranium exports, which was never intended to mean that the government would allow exports from any three mines. It more accurately should have been called the "three named mines policy", for the three mines that were in operation at the time the policy was instituted. It does not call for a replacement for the Nabarlek mine, which ceased operations in 1989. A widely-reported recent policy change in Australia was the elimination of the fixed floor-price requirement for long-term sales contracts. These and other aspects of Australia's uranium policy are currently under review by the Labor Party. The results of the review will be considered at the next regular party conference in mid-1991.

World Uranium Supply and Demand and the Potential Impact of Developments in Eastern Europe

Jan Murray, the Secretary-General for The Uranium Institute, discussed the opening of Chinese, Soviet, and East European markets, and their effect on world uranium supply and demand. Although it is no longer valid to restrict supply and demand analysis to western countries, there is little clear information available for the East European countries; in fact, uranium production data is still officially classified in the USSR. Available estimates suggest that production in the USSR is second only to Canada, and that its inventory exceeds 200 thousand tons U.

Canadian Uranium Industry

Robert Morrison, Director General for the Electricity Branch of the Canadian Department of Energy, Mines and Resources, discussed recent developments in the Canadian uranium industry and in uranium export policies. The changes are designed to promote economic development, exports, and investment in the Canadian uranium mining industry. They include: the maximum approval period on export contracts doubled to 30 years; government requirements that uranium contracts cover all future supply needs of individual Canadian utilities have been eliminated; pricing review criteria have been restated; uranium further-processing exemption criteria have been simplified; and foreign ownership limits have been increased.

Session 3: Uranium Consumers: The Utility Perspective

Nuclear Fuel Supply Implications of Ontario Hydro's Energy Supply Plan

Mr. E.G. Bazeley, Nuclear Fuel Supply Manager, reported on Ontario Hydro's demand/supply plan. Ontario Hydro utilizes demand-driven electricity growth forecasts to estimate future supply needs. In December 1989, Ontario Hydro completed its demand/supply plan; it calls for purchasing power from Manitoba, building 32 fossil fuel plants starting in 2001, and adding 10 new 880-MW reactors beginning in 2003. The utility projects it will be able to acquire the nuclear fuel necessary to meet demand without undue difficulty.

Uranium Procurement at TVO

Ilkka Mikkola, manager of TVO's Nuclear Fuel Office, discussed TVO's uranium procurement policy. Like many smaller European countries, Finland is largely dependent on imports for energy production. Thus, in contrast to some US utilities' procurement strategies, TVO places a high priority on security of supply, but within competitive constraints.

Uranium Procurement Strategy of a US Utility

Superintendent of Northern States Power's (NSP) Nuclear Fuel Supply, Jim Karalus, advocated a progressive supply program. NSP essentially maintains zero inventory as a means of lowering inventory carrying costs, and lowering purchase costs. In fact, Mr Karalus stated that if material which has not yet been paid for is deleted, NSP probably has a negative inventory. At this time, NSP does

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not view security of supply as critical, given the oversupply of uranium worldwide. NSP management emphasizes a strategy that results in the lowest costs. Flexibility to achieve the lowest costs is important, so NSP's strategy will change as market situations change.

Nuclear Plant License Renewal and its Impact on Uranium Requirements

Rudy Grube, director of Fuel Management for Yankee Atomic Electric Company, argued that nuclear plant license renewal in the US is essential; 20-year renewals would be equivalent to building 50 new nuclear plants. It would prevent the discharge of up to 11 billion tons of CO_2 and 182 million tons of SO_2 compared to the fossil fuel plants that would need to be constructed to replace nuclear electricity. License renewal would also provide electricity at one-tenth the cost of fossil plants of similar size ($150/kw vs. $1,500/kw). Mr. Grube emphasized that the process should be a re-licensing, not a new license procedure.

Uranium Market Trends and Utility Procurement Strategies for the '90s

Dave Clark, President of the Uranium Exchange Company, roused the emotions of many of the conference participants when he argued that security of supply should not be an issue for utilities, and that utilities should not subsidize producers with high-priced, long-term contracts. Mr. Clark said that the sooner buyers and sellers stopped being motivated by fear and greed, the sooner the laws of supply and demand can begin to work in the uranium market, which will, in turn, benefit both producers and utilities.

Session 4: Uranium Producers: The Mining Perspective

Eastern Europe's Uranium Production Capability

Wolfgang Kersting, the Managing Director of Germany's INTERURAN GmbH, covered the uranium production capability of the East European satellite countries, including East Germany, Czechoslovakia, Bulgaria, Romania and Hungary. Since 1946, most of their uranium production has been delivered to the USSR. With the recent changes in Eastern Europe, these countries will take control of their own operations, and will need to adopt western strategies to improve their efficiency and lower their costs, in order to compete in the new world market.

Namibia's Uranium Production

Michael Bates, the Chief Executive and Managing Director of Rössing Uranium Ltd., spoke about the Rössing mine, Namibia's sole uranium production operation, and the second largest uranium production operation in the world. Since Namibia gained independence from South Africa, economic sanctions on trade have been lifted. Exports from the Rössing mine account for approximately one-third the value of all exports from the new nation. Rössing's market strategy is to produce to meet contracted deliveries; once contracts exceed 10 million pounds U_3O_8 per year, Rössing has the ability to expand to meet further contracted demand.

Session 5: The International Uranium Industry: A Time of Change

Stocks and Trade with the Eastern Bloc— A Comparison of Uranium with other Metals

Alison Kidd, Senior Economist with RTZ Ltd., presented an analysis of the stocks and trade of some other base minerals (Al, Cu, Pb, Zn) and how trade with Eastern Bloc nations affected those metal markets. Because of the similarities of these markets to the uranium market, such as market oversupply, Ms. Kidd suggests that using analogies could offer an additional perspective on the effect of Eastern Bloc trade on the uranium market.

The Major Uranium Suppliers of the 1990s

Treva Klingbiel, Vice-President of NUEXCO Information Services discussed major uranium suppliers of the 1990s. Her speech is reprinted on pages 26-33 of this Report.

Uranium Resources: What's Happening in the Present Market

Mark Giroux, Uranium Market-Senior Analyst for COGEMA, raised questions on the true availability of uranium reserves in the years to come. Outlook from the consumers side is that of ample supply, with large excess inventories and the influx of material from the Eastern Bloc countries. Outlook from the producers' side is pessimistic, focusing on recent mine closures financial instability, and low uranium prices. With permitting delays and environmental concerns, the cost to restore world production capacity to the necessary future level may be higher than expected.

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WASHINGTON FOCUS

Congressional and administration negotiators concluded a five-year agreement intended to resolve the US government's budget and deficit problems as the fiscal year ended September 30. Congress must vote on the agreement and revise all 13 appropriations bills, including DOE and NRC appropriations. Increased NRC user fees and across-the-board energy taxes could be part of the final budget package. While Congress waited for the budget negotiators, work on other priority issues continued. Members considered the Clean Air bill, concluded the emissions section, and moved on to air toxics (which includes radionuclides).

Uranium Enrichment Bill's Last Chance This Year

◇ Senator Wendell Ford (D-KY) sent a message to the House that he is serious about enacting legislation restructuring DOE's uranium enrichment program. He attached the Uranium Enrichment Restructuring bill (S 83) as an amendment to two unrelated bills—a PURPA bill (Public Utility Regulatory Policies Act, S 2415), and a Federal Energy Regulatory Commission bill (S 3085). Reps. John Dingell (D-MI) and Philip Sharp (D-IN) sponsored PURPA legislation in the House, and the bill is awaiting House approval. Sen. Ford's action is designed to force Rep. Sharp to discuss uranium enrichment restructuring if he hopes to have Senate consideration of his own PURPA bill (HR 4808).

In the House of Representatives, the industry is encouraging the full Science, Space and Technology committee to hold a hearing and markup of an enrichment restructuring bill. Pressure is building to hold a hearing prior to the currently scheduled adjournment date of October 19. Unless Sen. Ford's strategy succeeds, perhaps in a lame duck session of Congress (a session held after an election but before new members are seated; members who have not been re-elected may still vote), the bill's proponents must begin the process anew next year.

Uranium Miners Compensation Bill Awaits President's Signature

◇ On September 27th, Congress approved and sent to the President for his signature, HR 2372–The Radiation Exposure Compensation Act. The bill creates a trust fund to compensate uranium miners in five Western states and citizens that lived downwind of the Nevada nuclear weapon test site in the 1940s and 1950s. UMETCO Minerals Corporation was primarily responsible for encouraging Congress to act on this bill. When the President signs the bill, it will set a precedent for federal responsibility in compensating uranium miners for cancer and other health problems resulting from practices established at the start of the nuclear weapons program.

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INDUSTRY BRIEFS

Swiss Voters Reject Phase Out, But Approve Nuclear Construction Moratorium

On September 23, Swiss voters rejected (53% to 47%) a proposal for the progressive abandonment of nuclear energy, which provides 40% of Switzerland's electricity production. However, a 55% majority approved another initiative calling for a 10-year moratorium on new nuclear plant construction or licensing. This proposal was viewed by the Swiss public as a compromise measure. Additionally, the Swiss solidly approved (71%) a measure that gives the federal government increased powers to control energy usage and requires the government to investigate alternative energy sources. Swiss voters had previously rejected anti-nuclear proposals, both in 1979 and in 1984.

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EdF Confirms Order For Civaux 1

EdF confirmed that it will order the construction of Civaux 1, a 1450-MWe (net) nuclear power unit. EdF will order the pressure vessel from Framatome in 1991. EdF probably will order Civaux 2, also a 1450-MWe (net) unit, in 1993.

NDP Surprise Victor in Ontario

The left-wing New Democratic Party (NDP), led by Bob Rae, surprised many observers by winning the majority of the seats in Ontario, Canada's September 6 provincial election. The anti-nuclear NDP took control of the government on October 1. The new energy minister will be Brian Charlton, who opposes nuclear power. He will be able to veto Ontario Hydro's recently completed 25-year energy plan, which includes plans for three new nuclear units. The ruling, pro-nuclear Liberal Party, which was in the third year of a five-year term, was trying to capitalize on recent high popularity in the polls by calling a quick election. A win would have returned them to power for five more years.

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Czechoslovakia Joins Foratom

Foratom, a non-governmental association of Western Europe's 13 national nuclear forums, announced September 4 that Czechoslovakia will become its first East European member. Foratom is likely to accept Hungary's national nuclear forum as the next.

Poland Abandons Zarnowiec

On September 4, the Polish government voted to abandon work on the reactors at Zarnowiec and to suspend any further nuclear projects until the year 2000. The two 440-MWe (net) VVERs were started in 1982, but are only 30% complete. Economic and technical problems have plagued the projects since their inception. Poland still will consider nuclear power projects for the future, and has set a goal to operate 2000 MWe of nuclear power by 2005.

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Cogema's UP3 Facility Operational

On August 26, Cogema's La Hague UP3 fuel reprocessing center became fully operational for the first time. The T1 shearing and dissolution unit had been the last incomplete process step. Most other steps in the process have been operating for some time. Cogema has contracts for approximately 7,000 MTU of reprocessing. The new line has a nominal capacity of 800 MTU per year.

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Wismut to Close Mining Operations

Wismut AG announced that its mining operations, consisting of six uranium mines and one uranium mill, will be closed by 1995. Wismut, based in East Germany, is an East German and Soviet uranium producing partnership (50%/50%) that was formed in 1954. It produced about 4,000 MTU equivalent U_3O_8 in 1989 and expects to produce 3,200 MTU this year. The Soviet Union has a contract, through the end of 1990, to take delivery of uranium mined by Wismut. However, the Soviet Union has announced it will not renew the delivery contract for 1991. The Soviet Union will remain a shareholder, but is not bound to maintain its interest at the present 50% level.

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Court Rules in Favor of US Goverment in Yucca Mtn. Waste Site

On September 19, the 9th US Circuit Court of Appeals in San Francisco ruled 3-0 that the US government can continue examining Yucca Mountain, Nevada as a potential location for the first US high-level nuclear waste site. The court ruled that the Nevada legislature's actions to prohibit storage of high-level nuclear waste were not binding on the federal government.

Italian Government Ratifies ENEL Reactor Shutdowns

The Italian government has formally ratified a July 12 resolution of the Italian Parliament that calls for the permanent closure of ENEL's Trino Vercellese and Caorso nuclear power plants. The resolution directs ENEL to put the plants in "passive protective custody" and to prepare decommissioning plans. Italy's Ministry of Industry, and its nuclear and alternative energy research agency, ENEA, still must approve the decommissioning plans before work can proceed. The government will ultimately reimburse ENEL for the decommissioning costs.

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Seabrook Enters Commercial Operation

After years of controversy, the Seabrook Nuclear Power Plant in New Hampshire entered commercial operation at the end of August. Seabrook recently completed over five months of power ascension tests. Unfortunately, the project's legal battles have not yet come to an end.

CORRECTIONS

In the July Monthly Report, #263, the article on Nukem's ownership change needs several corrections to Figure 1 (p.14). RBW holds a 50% interest, rather than 75%, in Uranerz Exploration and Mining Ltd. Also, RBW owns a 6.25% interest in Ranger (Australia), which was not indicated. In the legend, RBW should have been identified as Rheinbraun AG, as it was officially renamed last year.

The August Monthly Report, #264, under **Saskatchewan Revises Uranium Royalty System** (p.21), contains a typographical error in the reference to the 15% royalty assessed on gross sales. The basic minimum royalty is actually 5 percent, which may be used as a credit against any graduated royalties payable.

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THE MAJOR URANIUM SUPPLIERS OF THE 1990S

The following is an edited version of a speech presented by Treva Klingbiel, vice-president of NUEXCO Information Services, to the USCEA Uranium '90 Conference in San Antonio, Texas on September 19, 1990.

Between 1946 and 1990, the world uranium mining industry has experienced two complete boom/bust cycles. Each cycle has consisted of distinct and lengthy periods of expansion and consolidation, separated by a brief period of relative stability in the 1960s. Currently, the industry is in a consolidation phase with the strong getting stronger and the weak disappearing. A small number of producers have weathered this consolidation phase, and three have emerged as, and will likely remain, the major uranium producers in the 1990s. These three producers are: Cameco, Cogema, and RTZ.

From an economic viewpoint, it is generally accepted that such a consolidation results in greater price stability. This stability derives partly from reduced competition, which would normally result in increased prices. Currently however, significant new suppliers are emerging, resulting in increased competition, which may limit any significant price rise. These key competitors are the Soviet Union, China, and the Australian producers. As a group, they represent additional strong supply participants which will compete for world market share with the new "Big 3" of the 1990s.

The Uranium Market

Increasing prices encourage investment in the construction of new facilities. Decreasing prices force closures of production facilities. This relationship of activity and price is particularly evident in the USA. **Figure 1** illustrates the correlation between uranium prices and the number of uranium production centers. An interesting corollary to this trend is shown in **Figure 2**,

Figure 1
ACTIVITY vs. PRICE
IN THE URANIUM INDUSTRY

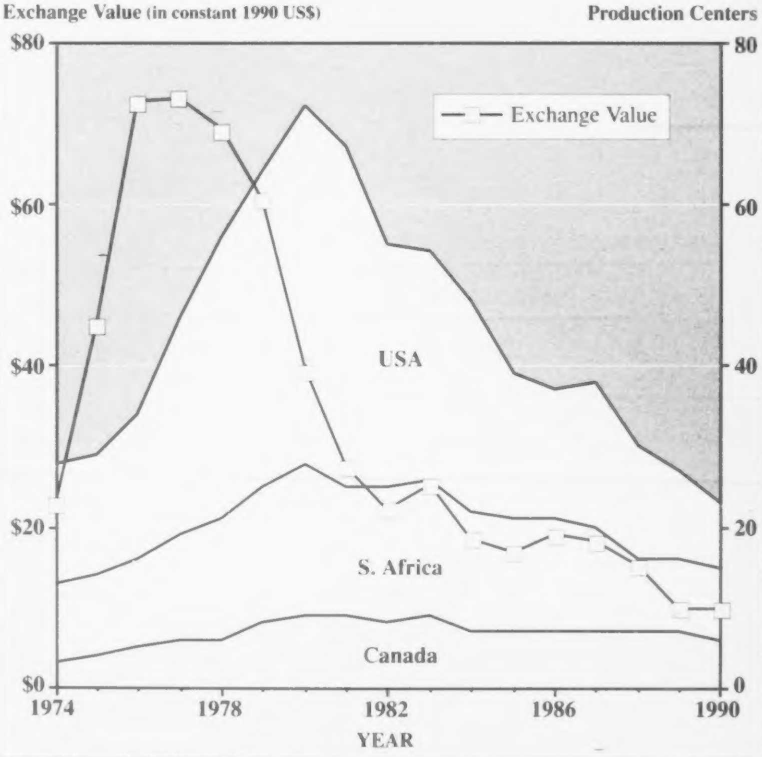

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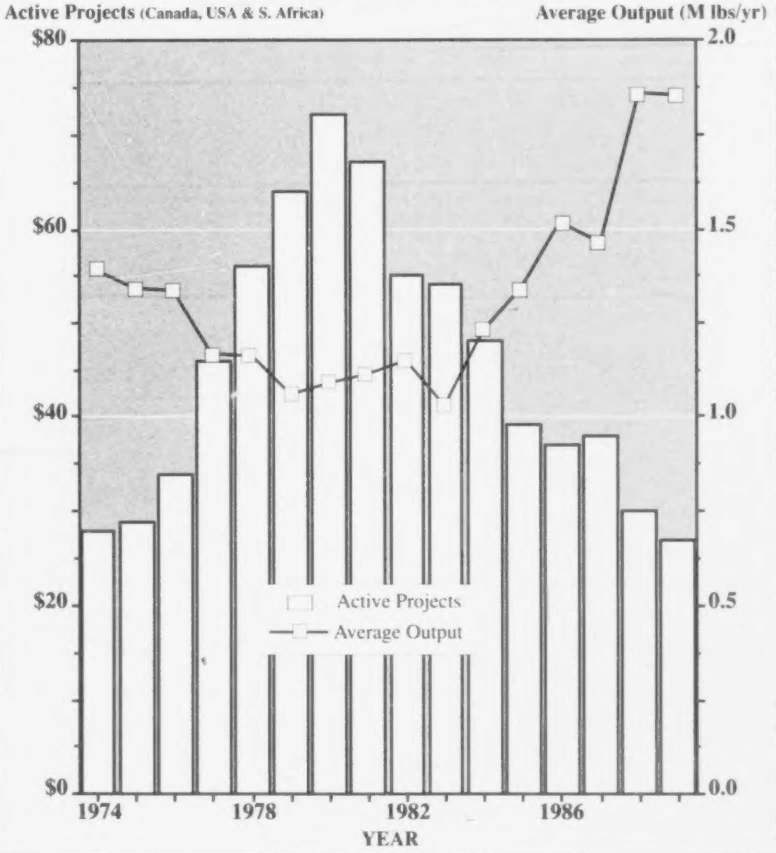
Figure 2
ACTIVITY vs. OUTPUT IN THE URANIUM INDUSTRY



where the average output per production center is shown to be inversely related to the number of production centers. Thus, larger production centers seem to survive better than smaller ones during periods of low prices, and indeed, this is borne out by the current period of consolidation.

NUEXCO counted a total of 57 uranium production centers in the western world in 1989. These centers produced a total of 89 million pounds equivalent U_3O_8 in 1989, an average of about 1.6 million pounds each. Much of this production was attributable to the new "Big 3," as shown in **Figure 3**. These three companies have at least a partial interest in 19 of the 57 active projects. The net interest of Cogema, Cameco and RTZ in 1989 production was over 41 million pounds, or about 45 percent of total production (**Table 1**). On a gross basis, however, the 19 projects in which these companies participated accounted for 62 million pounds or almost two-thirds of western world supply. This gross market share is expected to decrease only slightly through at least the mid 1990s.

Of the "Big 3" uranium companies, RTZ is the one most actively engaged in a program of acquisitions designed to increase its presence in the uranium industry. RTZ, through its subsidiaries, acquired the large, but mostly inactive, US uranium holdings of Kerr-McGee in 1989; a 50-percent interest in U.S. Energy's undeveloped Green Mountain project in 1990; and an eight-percent interest (expandable to a 25-percent interest) in the US solution mining company, Uranium Resources Inc., in 1990.

Cameco continues to add to its portfolio of properties through successful exploration efforts in Saskatchewan. It recently sold a one-third interest in its Rabbit Lake project (currently on standby) to Uranerz. Cogema is cutting back its domestic operations in France, but has added to its overseas interests in both Australia and the USA.

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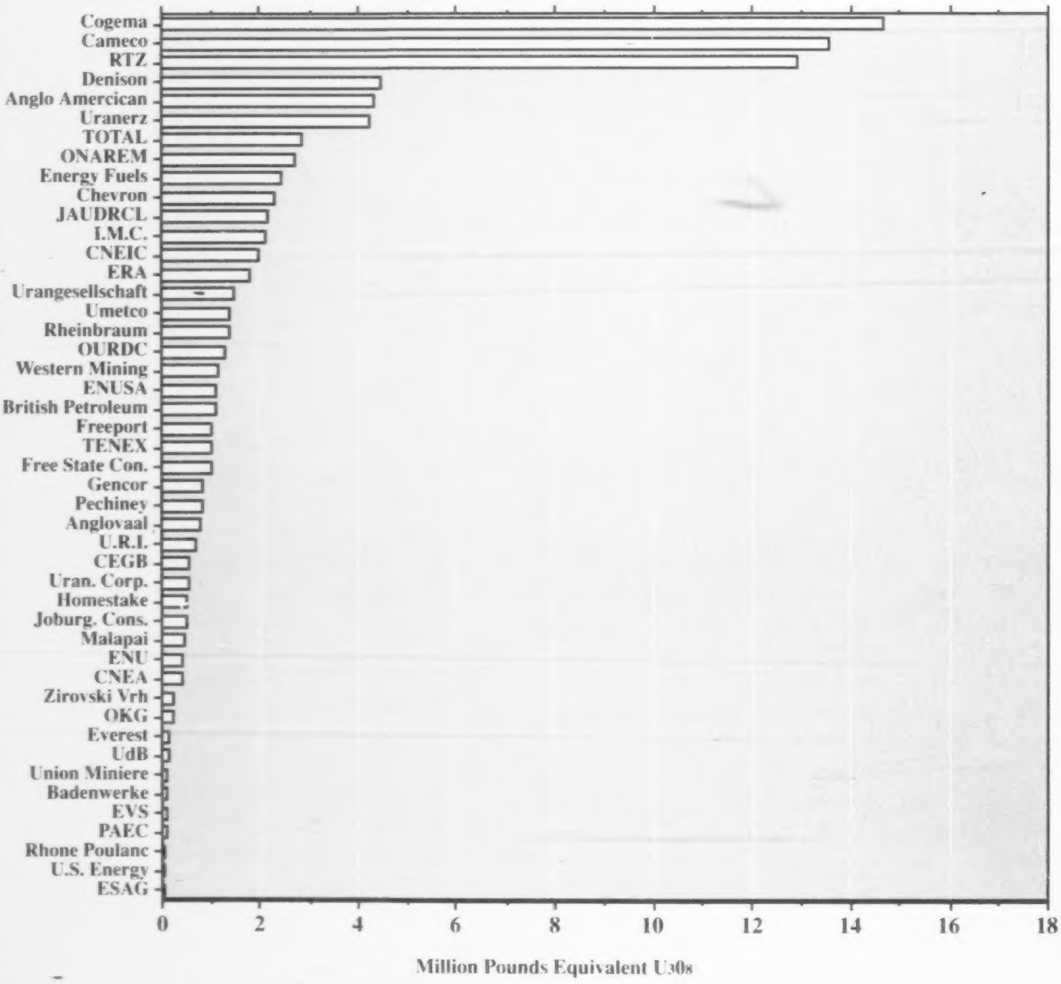
The Major Suppliers

Cogema

Cogema is a vertically-integrated uranium producer, focused on serving the French nuclear utility, Electricité de France. The ownership of Cogema is vested wholly in the French government. From its formation in 1945 through the mid-1970s, the French Commission for Atomic Energy (CEA) dominated uranium production in France. In 1976, the CEA transferred all its exploration and mining responsibilities to a newly-formed and wholly-owned subsidiary, Cogema (Compagnie Générale des Matières

Figure 3
ATTRIBUTABLE URANIUM PRODUCTION – 1989



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Nucléaires). Cogema assumed control of mining and milling operations in three districts of France, as well as exploration activities in France, Spain, Portugal, Zambia, and Australia. In addition, the company became involved in exploration, mining, and milling in Canada, Gabon, Niger, and the USA. Cogema currently has controlling interest in about 30 companies involved in various aspects of the nuclear fuel cycle, including uranium exploration, mining and milling, conversion, enrichment, fuel fabrication, spent fuel reprocessing, and other related activities.

Cameco

Cameco—A Canadian Mining and Energy Corporation, was formed in 1988 through the merger of Saskatchewan Mining Development Corporation (SMDC) and Eldorado Nuclear Limited. Cameco is the world's largest, low-cost producer of uranium, and is expected to remain in that position indefinitely. Cameco currently has interests in three major producing mines in northern Saskatchewan: Rabbit Lake ($66\frac{2}{3}$ percent), Key Lake ($66\frac{2}{3}$ percent), and Cluff Lake (20 percent). The ownership of Cameco is vested in the provincial government of Saskatchewan (61.5 percent) and the federal government of Canada (38.5 percent), but a series of public offerings is scheduled to privatize the company over a period of seven years. However, the first phase of privatization has been deferred due to low uranium prices.

Cameco is a vertically-integrated producer of nuclear fuel (for the CANDU heavy-water reactor), conversion services, and enrichment services. Its recently announced partnership with Isotope Technologies for development of the CRISLA process marked Cameco's entry into the enrichment market.

Table 1

DIRECT INTERESTS IN URANIUM PRODUCTION OF LARGEST THREE PRODUCERS

	Net Share of 1989 Uranium Concentrate Production		Participation in 1989 Uranium Concentrate Production	
Company	**Million Pounds U_3O_8**	**% of WOCA Supply**	**Million Pounds U_3O_8**	**% of WOCA Supply**
Cameco	13.5	15%	19.3	21%
Cogema	15.0	16%	28.0	30%
RTZ	12.9	14%	15.0	16%
TOTAL	**41.4**	**45%**	**59.51**	**64%**

RTZ

The RTZ Corporation PLC, formerly Rio Tinto Zinc Corporation PLC, is a British corporation originally formed in the 1800s to exploit copper deposits in Spain. RTZ's involvement in uranium production includes projects in Namibia, South Africa, Canada, USA, and Australia. RTZ's largest uranium production facility is the Rössing open-pit mine in Namibia which has a production capability in excess of ten million pounds equivalent U_3O_8 per year.

Notably, RTZ is the only major producer of the 1990s not directly owned by a government. Uranium accounts for only a small portion (less than five-percent) of RTZ's overall business interests, which revolve around mining and processing a wide range of other metals and minerals.

TENEX

TENEX, an acronym for V/O Techsnabexport, is the sole exporter of nuclear fuel components and services provided by the Soviet Union. It acts as an agent for the many producers of those items.

TENEX was founded in 1963, and until 1988 functioned within the Ministry of Foreign Trade and the Ministry of Foreign Economic Relations of the USSR. Currently, TENEX is a foreign economic organization of the Ministry of Atomic Energy and Industry. TENEX also exports a wide variety of technical products and technologies allied to both nuclear engineering and mineral production.

During the period 1945-1989, the Soviet Union built up a substantial stockpile of uranium in various forms through

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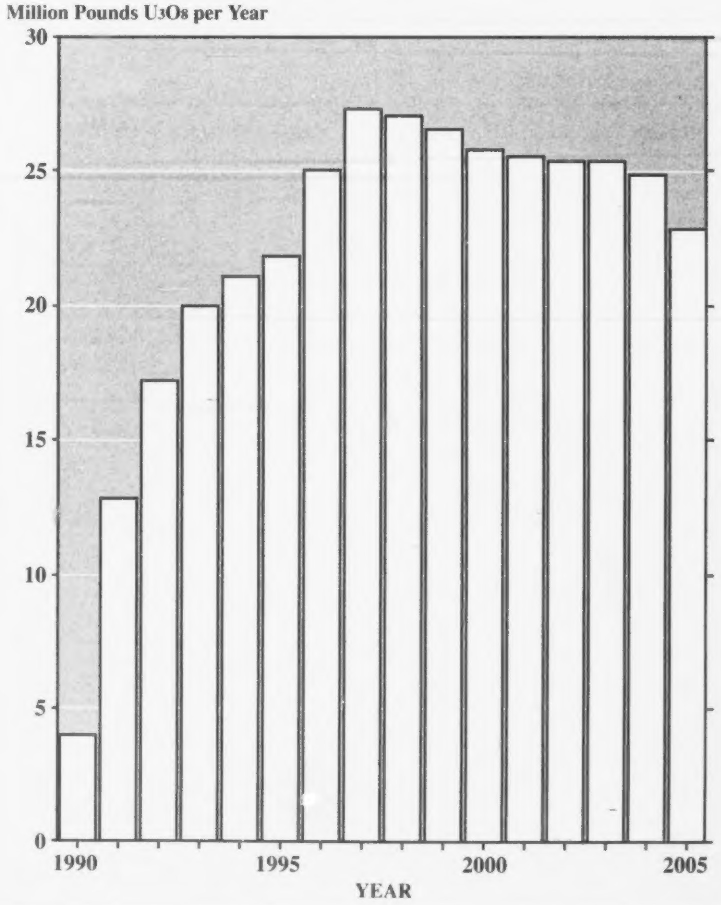
domestic production, and production of its Eastern European satellites, the production from which was totally tributary. Total Eastern European production for this period has been estimated to amount to over 1 billion pounds equivalent U_3O_8, or about 37 percent of world production.

Australia

Although Australia could account for over 27 percent of total world production, the Australian government's project approval process continues to hinder the development of most of this resource base. This approval process currently centers around the Australian Labor Party (ALP–the party presently in power), and the national conference (which is held every two years). In the 1984 conference, the ALP approved continued operations at Nabarlek, approved expanded production at Ranger, and permitted further development of the Olympic Dam project. The party rejected development of all other uranium deposits. These decisions are the basis of the federal government's "three-mine policy." The policy was never intended to mean that any three mines could operate, but rather, was a three *named* mines policy. The 1986 conference did not readdress the major uranium policy issues. In 1988, however, the ALP agreed to review the current policy through a special committee, which would ultimately put the issues to a ballot of conference delegates, either by mail or at the 1991 Conference. The biennial ALP national conference, originally scheduled for 1990, was delayed until 1991 because of the 1990 elections. While this review opens the door to a change in policy and signals the potential for a commercial orientation of Australia's uranium policy, actual implementation of any substantive changes could be some years away.

Figure 4
PRODUCTION CAPABILITY AVAILABLE
FROM FACILITIES ON STANDBY



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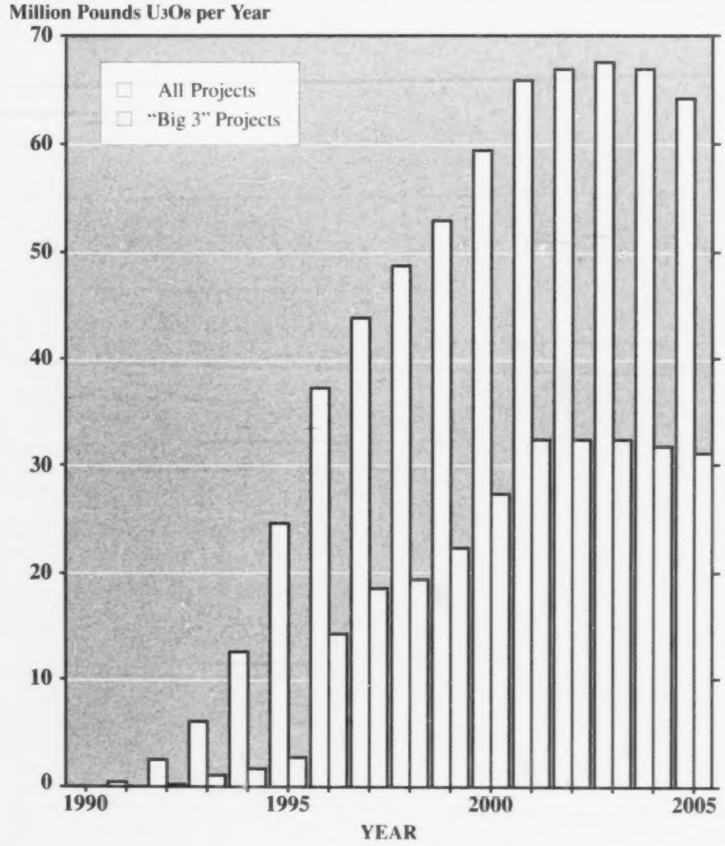
China

The China Nuclear Energy Industry Corporation (CNEIC) was established in 1980 by the government of the People's Republic of China (PRC). CNEIC's role is to handle all import and export activities of the China National Nuclear Corporation (CNNC), an organization reporting directly to China's Ministry of Energy Resources.

CNEIC is responsible for all imports and exports of CNNC, including export of nuclear equipment and instruments, technology, services, radioisotopes, chemicals, and other raw or upgraded materials. One of the most important sectors of CNEIC's activities relates to the export of all forms of uranium used in research and commercial reactors.

As the sole import and export authority of China's nuclear industry, CNEIC has been involved in the marketing and administration of all uranium and nuclear fuel transactions between the PRC and other countries throughout the world. The Nuclear Fuel Department of CNEIC is very active in Europe, and is playing a major role in the North American nuclear fuel market as well.

Figure 5
UNDEVELOPED PRODUCTION CAPABILITY



The Uranium Market of the 1990s

Through a combination of factors—including large inventories, low production costs, high ore grade, financial strength, and long-term commitments—four entities (Cameco, Cogema, RTZ, and the Soviet Union) are expected to achieve significant market share during the 1990s. National policy and market considerations will dictate whether the Australian producers and the Chinese aggressively enter into this competition. Market share will be achieved through a variety of activities including:

1) Continuing production from active projects;
2) Restart of projects currently on standby;
3) Development of new production from known deposits;
4) The discovery and development of new deposits.

TENEX, in contrast to the "Big 3", will fill its major role not through start-up of new projects and acquisitions, but through a balancing of stockpile sales and continuing production.

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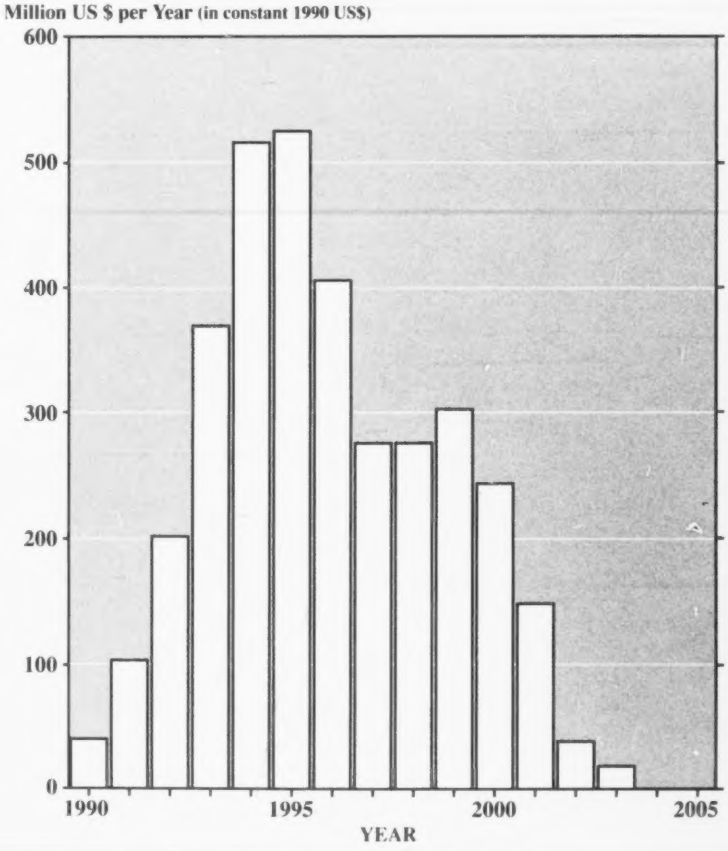
Historically low market prices (which have persisted for the past several years) have had, and will continue to have, an impact not only on existing operations but also on the development of new production centers, particularly in North America. The result of these low prices is that a number of producers have ceased operation and have placed their production facilities on standby. The combined production capability of facilities on standby is in the range of 30 million pounds equivalent U_3O_8 per year (see **Figure 4**). These facilities will reopen only if reasonable profits can be insured through long-term contracts, or if the projects seem sustainable at spot market prices. Canada, the USA, and South Africa all have substantial capacity that is currently on standby.

Past exploration activities have identified a significant number of potentially profitable uranium deposits that are as yet undeveloped. The production capability of this resource inventory is substantial (**Figure 5**). Cogema, Cameco, and RTZ each have at least two undeveloped projects which contribute to this future capability. However, a significant investment will be required to convert that capability into operating capacity. Historically, that required investment has averaged about $50 per pound U_3O_8 of annual capacity. **Figure 6** illustrates the investment requirement necessary to develop the new production capability shown in Figure 5.

A large portion of this undeveloped production capability exists in Australia where the continuing political debate has stalled most new projects for over 15 years. For this reason, it is unclear on what schedule and to what degree Australian producers will be able to participate in the market. Collectively, Australian producers have the potential to compete with the "Big 3" if they can overcome the potential hurdles.

Canada also has a large supply of undeveloped, low-cost resources which can play a major role in the 1990s. Unlike Australia, Canada's uranium policy has been very supportive of the industry and has made a substantial contribution to Canada's leading role in uranium production. Price levels will certainly need to show improvement in order for exploration efforts to increase.

Figure 6
CAPITAL INVESTMENT REQUIREMENTS FOR ADDED PRODUCTION CAPACITY



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Any judgement on the success of such exploration efforts is highly speculative, but, as with all commodities, the uranium industry can be expected to identify major new resources when it is economically motivated. The relative grade, as well as processing methodology, will be the major factors in the development of competitive new reserves.

Conclusion

Although we are in a period of consolidation, we can expect to see several new, non-traditional suppliers enter the market during the 1990s. The most likely candidates are the Soviet Union, China, and Australia. Other suppliers, such as Czechoslovakia and East Germany, can also be expected to put increasing pressure on western producers as they compete aggressively for market share. It will be interesting to follow the fates of the new "Big 3". Will they hold their market shares, or will other major players emerge? The uranium industry has changed markedly in the past; we think that activity will continue and those companies which have positioned themselves with a variety of low-cost reserves or supplies should be uniquely situated to take advantage of the forthcoming market opportunities. ■

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NATURAL URANIUM SUPPLY
1990—2005

This article summarizes sections of the Natural Uranium chapter of the 1990 NUEXCO Market Analysis and Price Trend Projections for Nuclear Fuel Materials and Services. *It discusses our forecast of uranium production, inventories, and supply capability for 1990–2005. The complete report, available from NUEXCO Information Services, presents a detailed market forecast.*

Overview

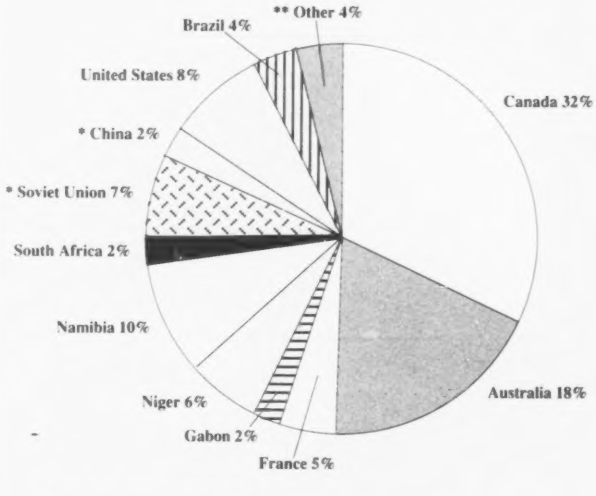
Given current production capacity, inventory levels, and additional production capability, the supply of natural uranium will be more than adequate to meet expected demand during the forecast period. However, temporary supply-demand imbalances will cause short-term variations in spot market prices.

NUEXCO projects cumulative world uranium requirements of 2.2 billion pounds equivalent U_3O_8 during the period 1990-2005. Inventory presently on hand will meet approximately 200 million pounds of those requirements; the balance must come from production. Thus, NUEXCO projects world uranium production will total 2.0 billion pounds equivalent U_3O_8 during the forecast period. Of that amount, 82 percent will come from "specified production" sources; production where the expected source, schedule, and production cost are specifically identified in the forecast. The remaining 18 percent must come from two areas:

- standby capacity that could be restarted;
- capacity that could be added by:
  - expanding existing facilities
  - developing new facilities and deposits.

In order to access the additional material needed to make the supply–demand equation balance, the price must increase enough to warrant the restart or addition of the new production capacity from what is now potential production capability. Is there enough uranium production capability? Without a doubt. Cumulatively, nearly 800 million pounds of standby capability and projected new capability will be available during the forecast period—more than double the estimated additional production needed. Furthermore, newly defined and discovered resources are projected to contribute an additional 100 million pounds equivalent U_3O_8 to world production capability by 2005. Canada and Australia will account for half of uranium production during 1990–2005 (**Figure 1**), and exports from the Soviet Union and China will make an increasing contribution to world supply.

Figure 1
TOTAL SPECIFIED PRODUCTION BY COUNTRY
1990-2005



* Expected exports from the Soviet Union and PRC.
** Other countries include Argentina, Belgium, Germany, India, Pakistan, Portugal, Spain, and Yugoslavia.

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Key Supply Sources

Australia

The Australian Labor Party (ALP) retained its majority in the March 1990 national elections. This leaves little near-term hope for a revision of Australia's three-mine policy, although the ALP has agreed to reconsider its policy and possibly modify it in the future. The ALP's strict floor-price policy finally succumbed to market forces within the last year; Australian producers may now receive approval from the government to sell uranium at prices that are "at least comparable with those received by others in the market." As some of the obstacles inhibiting competition are overcome, Australia's uranium producers will be able to make an increasing contribution to world supply; total production will exceed 300 million pounds equivalent U_3O_8 during 1990–2005.

Canada

Canada will remain the world's foremost uranium supplier; projected production through 2005 will exceed 500 million pounds equivalent U_3O_8. During 1989 and 1990, Cameco tested its market power as the world's largest uranium producer by:

- limiting its production;
- buying on the spot market to meet some current delivery commitments.

France

After a long period of stability, uranium production in France is beginning to decrease. With market prices consistently below production costs for several years, and generally low-grade ore now being mined, Cogema has announced plans to close its Vendée Mining Division. The Vendée division has been producing about 150-200 MTU per year, but its reserves are becoming very short. France's cumulative production through the year 2005 will fall in the range of 80 to 100 million pounds equivalent U_3O_8.

Production from Gabon and Niger, former French colonies, could total nearly 150 million pounds equivalent U_3O_8 if France continues to subsidize their production. However, by paying higher than market prices, France's willingness to renew its subsidies is subject to periodic internal review.

Southern Africa

Uranium production from South Africa remains burdened by low market prices and apartheid sanctions. As a result, production levels will continue to decline, possibly to an annual level of one million pounds equivalent U_3O_8 by the mid-1990s.

In contrast, the outlook for Namibia improved when it became independent in March 1990. Sanctions have been lifted and Rössing Uranium Ltd., Namibia's only uranium producer, is expected to boost production to near-capacity levels (10.5 million pounds equivalent U_3O_8 per year).

United States

US facilities will produce nearly 150 million pounds equivalent U_3O_8 during the period 1990–2005. As a result of continued low market prices, production will continue decrease through 1994. US production will rise late in the decade as some new projects start up, but several of these projects have limited reserves, so production will decline once again after 2000 as these reserves are depleted. Significant standby capacity in the USA could be used to take advantage of any price increases. However, large price increases are not expected, so the excess standby capacity can be expected to diminish as facilities deteriorate.

In-situ leaching is expected to account for an increasing share of future US uranium production, and conventional mining production centers may operate only intermittently during the mid-1990s. Only three conventional mills are still operating in the USA—Chevron's Panna Maria, Umetco/Energy Fuels' White Mesa, and Cogema's Shirley Basin.

Other Countries

Uranium production from other countries will grow only modestly during this decade, although it could begin to increase faster in the late 1990s. Most of the 125 million pounds equivalent U_3O_8 produced through the year 2005 will be dedicated to internal use. Of this group, only Brazil has enough resources to export significant quantities.

Exports

Uranium exports from countries with centrally-planned economies will account for an increasing share of world uranium supply. Most of the material will come from the Soviet Union and China. The Soviet Union's nuclear power program has slowed appreciably since Chernobyl, but uranium production has not. Some of this production, along with large stockpiles, will be made available to the rest of the world at competitive prices in order to generate much-needed hard currency. The Soviet Union has the capability to export as much as 10 million pounds equivalent U_3O_8 per year, but has been exporting only about 2-3 million pounds. Annual exports could exceed five million pounds by the mid-1990s.

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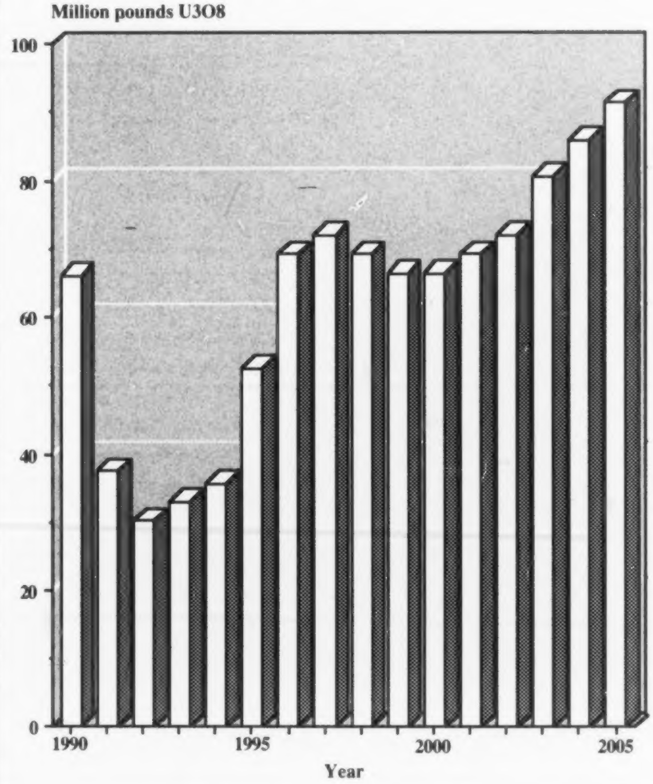
Figure 2
FORECAST OF NEW URANIUM DISCOVERIES



China can be expected to offer moderate quantities of uranium into the international market, at least until its own nuclear power program begins to require the material in the latter part of this decade. At current prices however, China has been somewhat reluctant to make aggressive sales efforts.

Exploration and Development

With the decline of uranium prices in the 1980s came a decline in exploration and development expenditures. Based upon historical data, this relationship between uranium prices and exploration expenditures (and subsequent reserve discoveries) is statistically significant and can be used to develop a predictive model. Using a linear regression model of uranium price and exploration expenditures, future expenditures can be predicted. From that forecast, new uranium discoveries can be projected (**Figure 2**). Because discovery and exploitation of reserves follow years after the related exploration expenditures, a lagging factor has been incorporated into the predictive model that projects additions to currently known production capability. Even with this seven-year time lag, NUEXCO forecasts that 100 million pounds equivalent U_3O_8 could be produced from newly-discovered reserves by 2005.

Inventories

Uranium inventories have frequently been classified as having three separate components:

- In-Process Inventory—also referred to as pipeline material or working stock—is uranium at some stage of processing into fuel assemblies.
- Reserve Inventory—also called contingency or strategic inventory—is uranium intentionally held over-and-above the in-process inventory, in order to ensure that uranium will always be available when needed. It protects against unexpected delivery interruptions or unanticipated uranium needs.
- Excess Inventory—is the amount on hand that exceeds the combination of in-process and reserve inventories.

The classification of inventory into these three categories is not straightforward; definitions can be somewhat fluid, and inventory can be reclassified at any time depending on the perceptions of the market supply situation. If uranium is expected to be plentiful, then reserve inventory is reduced, and vice versa. Historically, the tendency has been to reclassify excess inventory and hold it for the future, rather than to sell it. However, there is a growing tendency, particularly among US and European utilities, to put excess inventory to use, either through loans or sales. So although the absolute level of sales of inventory material may be less than earlier years, the number of entities using market mechanisms such as loans is increasing.

NUEXCO estimates the level of commercial inventories at 450 million pounds equivalent U_3O_8 as of January 1, 1990, about four percent less than one year earlier.

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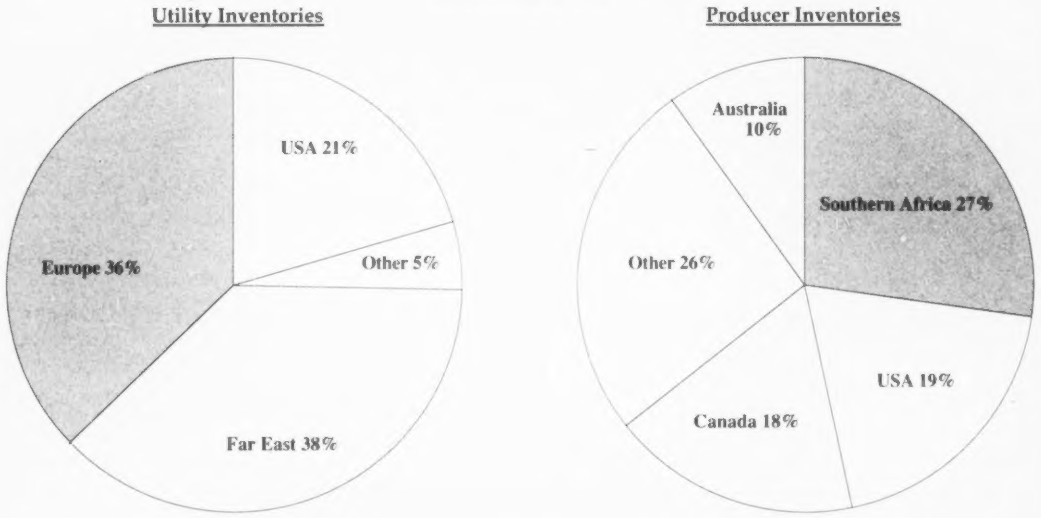
Figure 3
UTILITY AND PRODUCER INVENTORIES BY REGION
(as of January 1, 1990)



Total estimated inventory = 450 million pounds equivalent U_3O_8

NUEXCO's inventory figures indicate the amount of material that could be made available to the market, including any material that could become available by means of a policy decision by a company or government. In-process material is also included, since NUEXCO views the pipeline as a location parameter. Material that NUEXCO judges as strictly strategic and not likely to be consumed by the country's reactors, or be made available for sale, is not included. Of the 450 million pounds, approximately one-third is considered excess, based upon the following reserve inventory requirements by region.

● United States	1 year
● Europe	2 years
● Far East	4 years
● Other Countries	1 year

Reserve inventory policy is subject to many factors, of which, one of the most important is assurance of supply. For instance, the availability of domestic supplies typically allows North American utilities to maintain much lower strategic reserves than utilities in the Far East. **Figure 3** shows the proportion of the world's utility and producer inventories by region.

Supply/Demand Balance

As reviewed in the July Monthly Report (#263 p. 22), NUEXCO projects cumulative uranium requirements of more than 2.2 billion pounds equivalent U_3O_8 during the period 1990-2005. Of those requirements, only 64 percent are presently covered by current inventories or contracts. Therefore, requirements of approximately 800 million pounds equivalent U_3O_8 remain unfilled via contracts. With only 33 percent forward coverage, the USA has the largest unfilled requirements over the forecast period; other regions have substantially higher levels of coverage. (Details of unfilled requirements by country and by company, are included in the complete report.) The market will be particularly active in the USA until excess inventories are drawn down. This equalization of excess supply with demand will occur in 1994-95, although supply will remain ample through the year 2005. ■

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NUCLEAR INDUSTRY CALENDAR

Nov. 11-14	*Nuclear Energy Forum* (Washington Hilton, Washington, D.C.). Sponsored by the USCEA and ANS. Contact: USCEA Conference Office at 202-293-0770, or ANS Meetings Department at 312-352-6611.
Nov. 12-16	***First Regional Seminar for Europe and the Middle East on Quality Management for Nuclear Power Projects*** (Prague, Czechoslovakia). Sponsored by the IAEA. Contact: Conference Service Section, IAEA, P.O. Box 100, A-1400 Vienna, Austria.
Nov. 12-13	***Fourth World Electricity Conference*** (London, England). Sponsored by The Financial Times Ltd. Contact: Financial Times Conference Organisation: 71-925-2323, Telex: 27347, Fax: 71-925-2125.
1991	
Jan. 13-16	*Nuclear Insurance Conference* (The Peabody Orlando Hotel, Orlando, Florida). Sponsored by the USCEA. Contact: USCEA Conference Office: 202-293-0770, Telex: 7108249602, Fax:202-785-4113.
March 24-27	*Fuel Cycle Conference '91* (Sheraton Scottsdale Hotel, Phoenix, Arizona). Sponsored by the USCEA. Contact: USCEA Conference Office: 202-293-0770, Telex: 7108249602, Fax:202-785-4113.
April 14-17	*INFO '91 Conference* (The Westin Hotel, Chicago, Illinois). Sponsored by the USCEA. Contact: USCEA Conference Office: 202-293-0770, Telex: 7108249602, Fax:202-785-4113.
April 14-18	***Third International Conference on Nuclear Fuel Reprocessing & Waste Management*** (Sendai, Japan). Sponsored by the Atomic Energy Society of Japan and the Japan Atomic Industrial Forum, co-sponsored by the American Nuclear Society and the European Nuclear Society. Contact: Japan Atomic Industrial Forum at 3-508-2411, or by facsimile at 3-508-2094.
May 13-15	***Second International Conference on Transportation for the Nuclear Industry*** (Bournemouth, England). Contact: Conference Secretary, The Institution of Nuclear Engineers at 081-698 1500.
June 23-26	***International Conference on Enrichment*** (The Westin Hotel, Washington, D.C.). Sponsored by the USCEA. Contact: USCEA Conference Office: 202-293-0770, Telex: 7108249602, Fax:202-785-4113.
Sept. 22-25	***International Uranium Seminar '91*** (The Don Cesar Hotel, St. Petersburg/Tampa, Florida). Sponsored by the USCEA. Contact: USCEA Conference Office: 202-293-0770, Telex: 7108249602, Fax:202-785-4113.
Nov. 10-13	***Nuclear Energy Forum*** (Westin St. Francis Hotel, San Francisco, California). Sponsored by the USCEA. Contact: USCEA Conference Office: 202-293-0770, Telex: 7108249602, Fax:202-785-4113.

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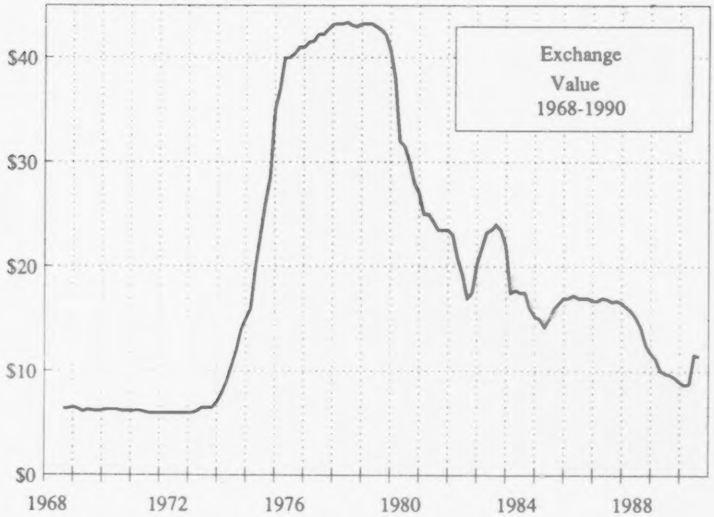
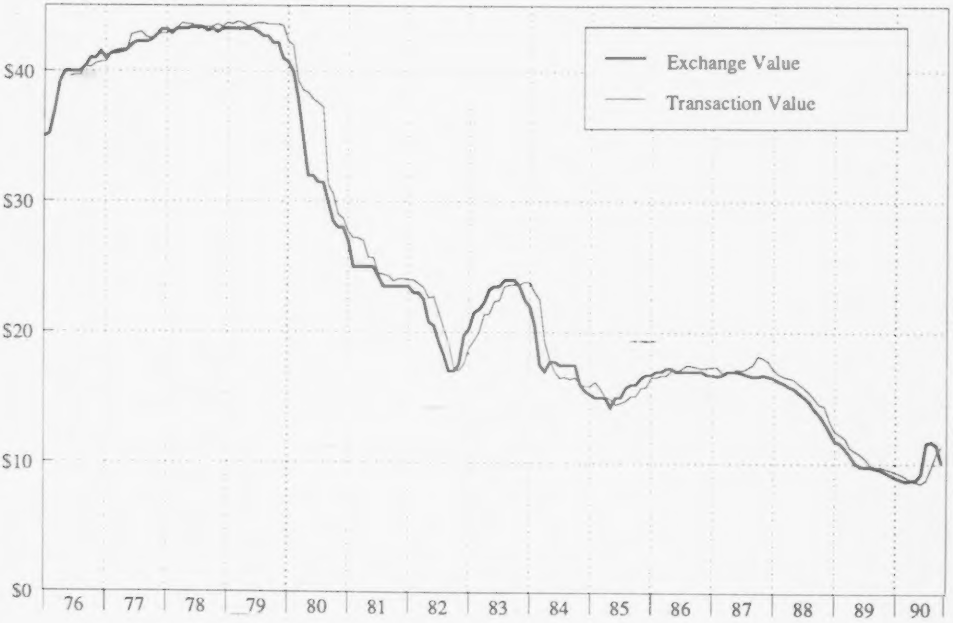
HISTORICAL MARKET DATA

NUEXCO Historical Exchange Value and Transaction Value

(In US Dollars per Pound Equivalent U3O8)





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HISTORICAL MARKET VALUES

EXCHANGE VALUES

Determined as of the last day of the month indicated ($US/lb U_3O_8)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	16.75	16.65	16.65	16.75	16.65	16.55
1988	16.30	16.15	15.90	15.75	15.40	15.10	14.75	14.15	13.75	13.15	12.50	11.75
1989	11.60	11.20	10.70	10.10	9.85	9.80	9.80	9.70	9.60	9.40	9.20	9.00
1990	8.85	8.70	8.80	8.80	9.25	11.60	11.70	11.45	**10.10**			

US PREMIUM (Relative to the Exchange Value)

Determined as of the last day of the month indicated ($US/lb U_3O_8)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	0.65	0.75
1987	0.85	1.00	1.50	1.50	0.90	0.60	2.50	2.35	2.10	1.65	0.85	0.65
1988	0.70	0.50	0.15	0.25	0.60	0.00	0.00	0.00	0.00	0.00	**Discontinued**	

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UF6 VALUES

Determined as of the last day of the month indicated ($US/kg U as UF_6)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	47.50	47.00	46.75	47.00	47.00	47.00
1988	46.50	46.00	45.50	45.25	44.75	44.00	42.75	41.00	40.75	39.00	37.50	35.50
1989	34.75	34.00	33.00	30.50	30.25	30.25	30.00	29.75	29.75	28.25	27.75	26.50
1990	25.90	25.25	24.40	24.40	25.50	32.00	32.50	32.25	**29.50**			

US UF6 PREMIUM (Relative to the UF6 Value)

Determined as of the last day of the month indicated ($US/kg U as UF_6)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	2.50	2.50
1987	2.50	2.50	3.50	3.00	2.25	1.75	6.50	6.00	4.25	3.10	2.25	2.00
1988	1.25	1.25	0.50	0.50	1.00	0.00	0.00	0.00	0.00	0.00	**Discontinued**	

TRANSACTION VALUES

Determined as of the last day of the month indicated ($US/lb U_3O_8)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	17.30	17.55	18.20	18.05	17.80	17.20
1988	16.85	16.65	16.55	16.45	16.10	15.80	15.45	15.00	14.50	14.40	13.30	12.50
1989	12.25	12.00	11.25	11.00	10.75	10.45	9.95	9.80	9.80	9.65	9.55	9.40
1990	9.25	9.05	8.75	8.65	8.55	8.80	9.75	10.80	**11.40**			

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LOAN RATES

Determined as of the last day of the month indicated (Percent per Annum)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	4.00	4.00	4.00	4.00	4.00
1969	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00	6.00	6.00	6.00	6.00
1970	6.00	6.20	6.40	6.50	6.50	6.50	6.50	5.00	6.50	6.00	5.50	5.50
1971	5.00	4.75	4.75	4.75	5.00	5.25	5.25	5.25	5.25	5.25	4.50	4.50
1972	4.00	4.00	4.00	4.50	4.50	4.50	5.00	5.00	5.00	5.00	5.00	5.00
1973	5.50	5.50	5.75	5.75	6.00	6.25	7.00	7.00	7.00	7.00	7.50	8.00
1974	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
1975	8.00	7.00	7.00	7.00	7.00	6.50	6.50	6.50	6.50	6.50	6.50	6.50
1976	6.50	6.50	6.50	6.50	*	*	*	*	*	*	*	*
1977	*	*	*	*	6.50	6.50	6.50	6.75	7.25	7.25	7.25	7.25
1978	7.25	7.00	7.00	7.00	7.00	7.50	7.75	7.75	7.75	7.00	7.00	7.00
1979	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1980	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
1981	7.00	7.00	7.00	7.00	7.00	5.50	5.50	5.50	5.50	6.00	6.00	6.00
1982	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1983	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1984	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
1985	6.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
1986	5.00	5.00	5.00	5.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
1987	3.00	3.00	3.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00	3.50	3.50
1988	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
1989	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
1990	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	**3.50**			

* Float with Prime Rate

CONVERSION VALUES

Determined as of the last day of the month indicated ($US/lb U as UF6)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.90	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.90	1.90	1.90
1988	1.90	1.80	1.80	1.80	1.80	1.80	1.85	1.95	1.95	1.95	1.95	1.95
1989	1.95	1.95	1.95	1.95	1.95	1.95	1.95	1.90	1.90	1.80	1.75	1.65
1990	1.50	1.50	1.45	1.45	1.45	1.45	1.45	1.45	**1.45**			

SWU VALUES

Determined as of the last day of the month indicated ($US per SWU)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	80	80	80	80	75	78	78	78	78	78	80	80
1987	80	80	77	77	75	73	75	75	73	69	73	73
1988	73	73	70	68	68	68	68	65	65	65	65	65
1989	65	67	67	67	66	66	66	65	63	59	57	54
1990	54	50	50	50	50	50	50	50	**50**			

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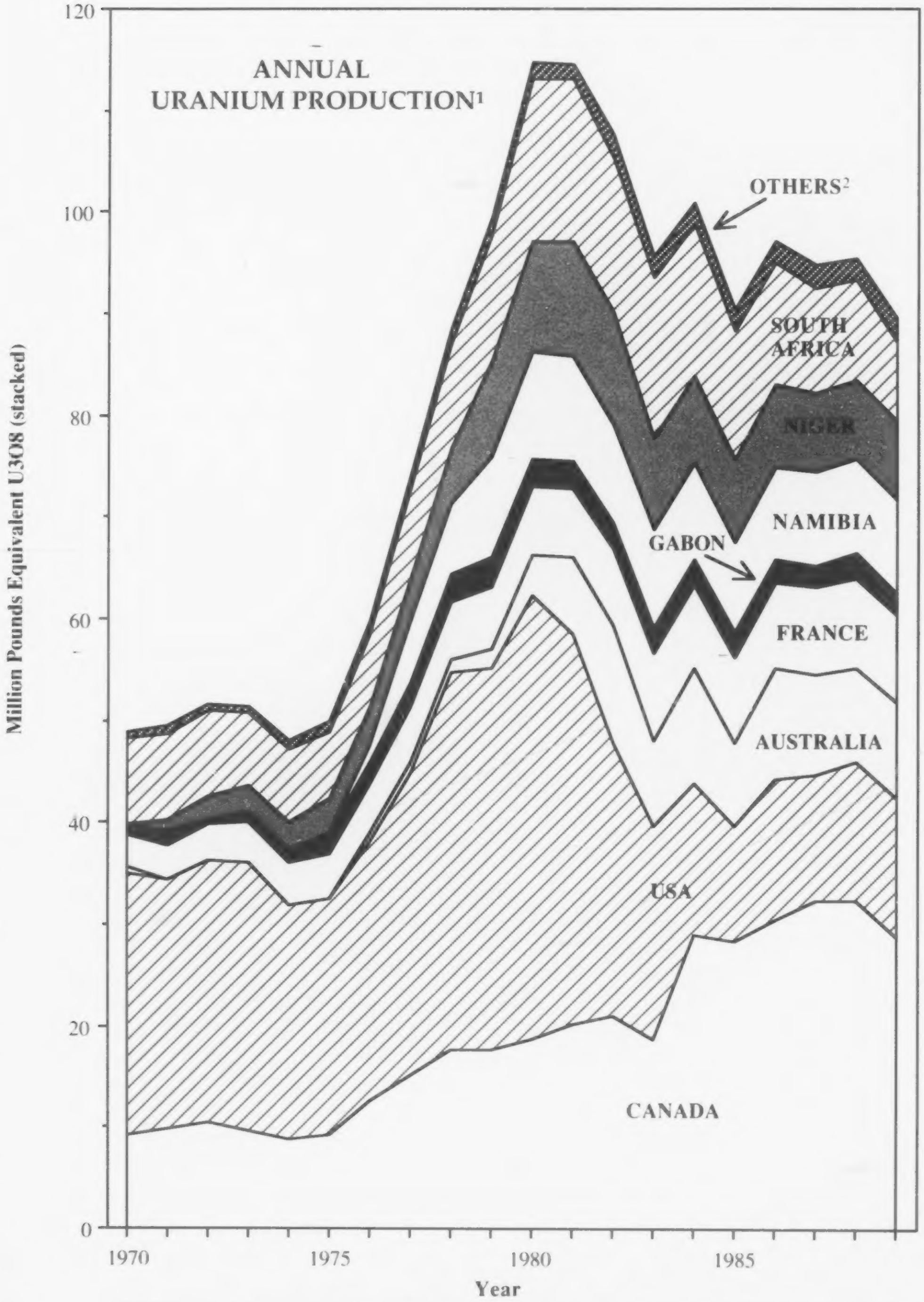

ANNUAL URANIUM PRODUCTION[1]

[1] Estimated world production in 1989 totalled 89.6 million pounds (Australia—9.5; Canada—28.7; France—8.5; Gabon—2.2; Namibia—9.2; Niger—7.7; South Africa—7.7; USA—13.7; Others[2]—2.3).

[2] **Others** includes: Argentina, Belgium, Brazil, India, Pakistan, Portugal, Spain, West Germany and Yugoslavia

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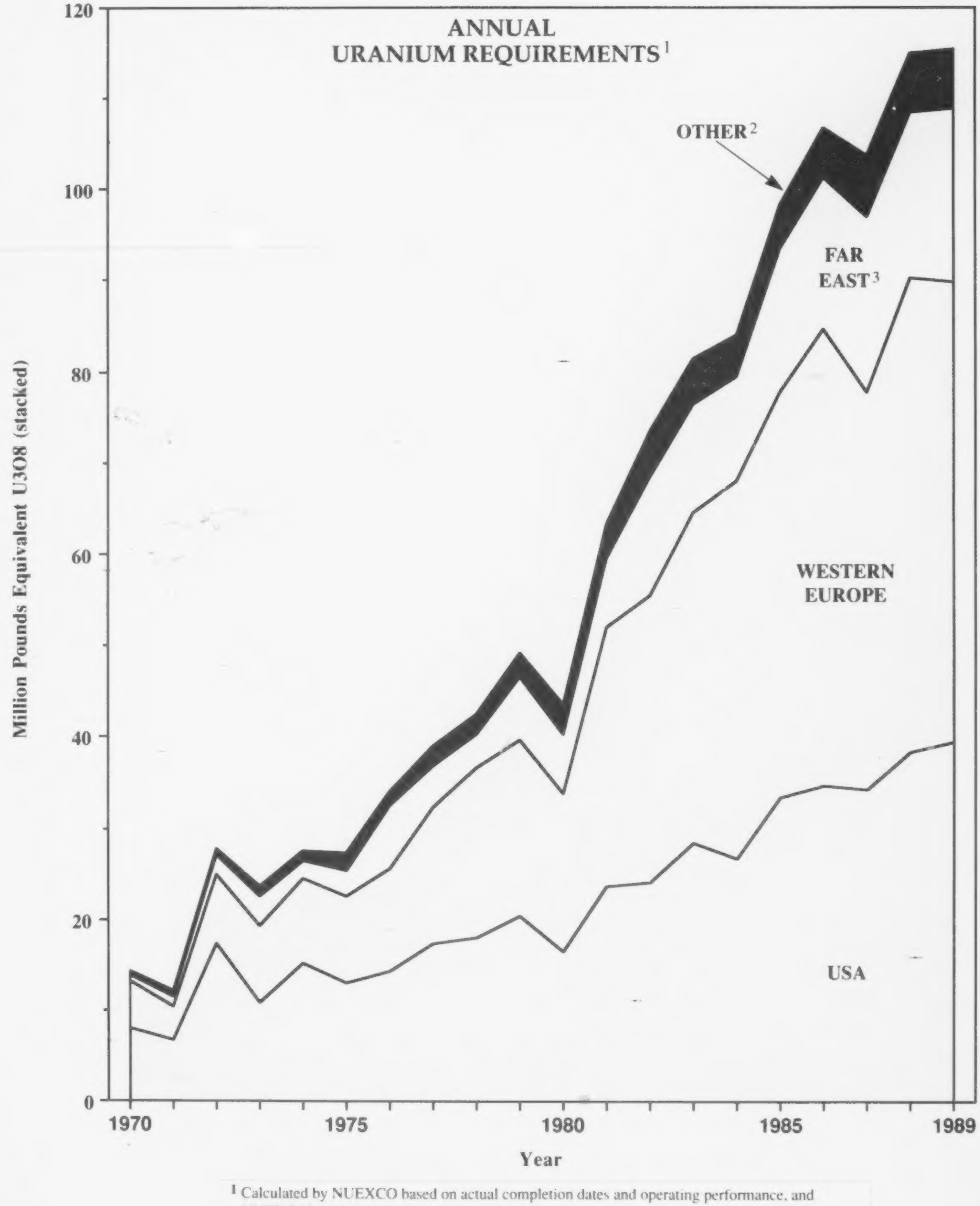
HISTORICAL MARKET DATA



[1] Calculated by NUEXCO based on actual completion dates and operating performance, and NUEXCO's estimate of enriching tails assays.

[2] **Other** include: Argentina, Brazil, Canada, India, Mexico, Pakistan and South Africa.

[3] Does not include Peoples Republic of China.

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AUSTRALIA

Year	Period[1]	Consumer Price Index[2] (1980/1981 = 100)	Price Index of Materials Used in Manufacturing Industry — All Groups[3] (1984/1985 = 100)	Average Weekly Ordinary Time Earnings — Adult Males — Australia[4] (Australian dollars)	Award Rates of Pay Indexes Australia - Adult Males In Mining Wage Earners, Weekly Rates[5] (June 1985=100)
1980	Avg.	95.8	83.1	—	140.8[6]
1981	Avg.	105.0	85.9	—	154.1[6]
1982	Avg.	116.7	89.0	—	174.9[6]
1983	Avg.	128.5	96.9	—	181.9[6]
1984	Avg.	133.6	98.0	—	194.4[6]
1985	Avg.	142.6	107.3	—	103.7
1986	Avg.	155.5	101.5	—	106.1
1987	Avg.	168.7	108.9	465.88	112.3
1988	Avg.	180.9	111.8	496.90	115.2
1989	Avg.	194.6	117.0	534.65	126.0
Jan	1990	—	119.2	—	128.0
Feb	1990	—	120.8	—	128.0
Mar	1990	204.1	121.5	—	128.2
Apr	1990	—	119.9	—	128.5
May	1990	—	118.9	—	128.7
June	1990	—	116.6	—	—

P = Preliminary **R** = Revised since last month

[1] Monthly data for the period 1967 to 1986 appears in Report 233 (January 1988).
[2] Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: Financial year July 1980 to June 1981 =100.0). Figures shown at end of quarter represent quarterly average.
[3] Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0).
[4] Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.
[5] Australian Bureau of Statistics, Canberra: "Average Weekly Earnings, States & Australia" (Catalogue No. 6302.0).
[6] Base: June 1976 = 100.

CANADA

		Industrial Products Price Index: All Commodities[1] (1986 = 100)[2]	Consumer Price Index: All Items (1986 = 100)[3]	Wage-earner Data: Average Hourly Earnings (C$)[4]				
				Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells (SIC 051-099)	Metal Rolling, Casting and Extruding (SIC 298)	Chemicals and Chemical Products Industries (SIC 372-379)
1980	Avg.	75.7	67.1	—	—	—	—	—
1981	Avg.	83.4	75.5	—	—	—	—	—
1982	Avg.	89.0	83.7	—	—	—	—	—
1983	Avg.	92.1	88.5	17.22	—	14.18	10.67	11.10
1984	Avg.	96.3	92.3	17.89	—	14.97	11.11	11.68
1985	Avg.	99.0	96.0	18.53	16.48	15.56	11.85	12.12
1986	Avg.	100.0	100.0	19.38	16.70	15.76	12.28	12.58
1987	Avg.	102.4	104.4	20.12	17.15	16.11	12.58	13.20
1988	Avg.	106.9	108.6	20.91	18.51	16.95	13.17	13.77
1989	Avg.	109.4	114.0	21.97	20.02	18.41	13.71	14.16
Jan	1990	108.7	116.9	21.88	20.39	19.03	13.99	14.78
Feb	1990	109.3	117.6	22.51	20.63	19.14	14.49	15.03
Mar	1990	109.2	118.0	22.52	20.75	19.17	14.99	15.07
Apr	1990	109.1	118.1	23.17	21.20	19.46	14.83	14.93
May	1990	109.5	118.7	23.28	20.55	19.01	14.71	15.06
June	1990	109.4	119.2	21.85R	20.63R	18.96R	14.69R	15.05R
July	1990	109.1	119.8	22.49P	20.48P	18.76P	14.49P	15.20P
Aug	1990	109.2	119.8	—	—	—	—	—

P = Preliminary **R** = Revised since last month

[1] Statistics Canada, Prices Division, Ottawa: “Industry Price Indexes” (Catalogue 62-0II). Indexes for the most recent six months shown are subject to revision. This category was formerly known as “Manufacturing.” Monthly data for the period 1967 to 1986 is found in Report 233.

[2] New Base Year of 1986 as of Report 266. Previous Base Year was 1981. All figures in column recalculated by 0.791 multiplier.

[3] New Base Year of 1986 as of Report 264. Previous Base Year was 1981. All figures in column recalculated by 0.755 multiplier.

[4] Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa [illegible] Employment, Earnings and Hours.” Monthly data for the period 1983 to 1986 is found in Report 233.

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SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled[1] (Rand)	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled[2] (March 1982 = 100)	Consumer Price Index[3] (1985 = 100)	Production Price Index All Groups[4] (1985 = 100)	Total Employment in Mining and Quarrying[5]	Total Salaries and Wages in Mining and Quarrying[5] (1,000 Rand)
							Annual Total[6]
1980	Avg.	35.53	—	51.9	55.2	709,042	2,237,689
1981	Avg.	41.89	—	59.8	62.7	722,918	2,756,928
1982	Avg.	47.25	104.2	68.6	71.4	702,041	3,181,584
1983	Avg.	51.88	115.0	77.1	79.0	700,901	3,563,282
1984	Avg.	58.95	130.3	86.0	85.6	711,511	4,134,390
1985	Avg.	68.76	151.6	100.0	100.0	724,587	4,778,612
1986	Avg.	80.22	177.9	118.6	119.5	756,637	5,767,950
1987	Avg.	95.01	223.1	137.7	136.2	751,864	6,911,395
1988	Avg.	106.69	241.1	155.4	154.1	705,355	7,774,054
1989	Avg.	116.65	273.0	178.2	177.5	700,360	8,833,934
							Monthly Total
Jan	1990	—	—	192.0	188.8	688,837	801,616
Feb	1990	—	—	193.3	190.3	674,026	767,274
Mar	1990	126.74	296.3	196.4	190.9	704,660R	780,614R
Apr	1990	—	—	198.3	194.1	696,107	810,474
May	1990	—	—	200.4	196.3	613,527	719,191
June	1990	128.25	299.87	201.8	197.0	—	—
July	1990	—	—	203.2	197.2	—	—
Aug	1990	—	—	206.5	—	—	—

P = Preliminary R = Revised since last month

[1] Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly. Historical Data by month appears in Report 236.

[2] Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3] Central Statistical Service, Pretoria: All income groups-weighted average, Historical Data by month appears in Report 236.

[4] Central Statistical Service, Pretoria: All commodities for consumption in South Africa.

[5] Central Statistical Service, Pretoria: Historical Data by month appears in Report 236.

[6] Annual total is shown, rather than monthly average for indicated year.

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GOVERNMENT STATISTICS

UNITED STATES

		Producer Price Index[1]		Consumer Price Index[2] (1982-1984 = 100)	GNP Implicit Price Deflator[3] (1982 = 100)	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4]			
		Industrial Commodities (1982 = 100)	All Commodities (1982 = 100)			Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980	Avg.	88.0	89.8	82.4	85.7	10.26	10.63	8.30	6.94
1981	Avg.	97.4	98.0	90.9	94.0	11.55	11.98	9.12	7.62
1982	Avg.	100.0	100.0	96.5	100.0	12.31	12.93	9.96	8.21
1983	Avg.	101.1	101.3	99.6	103.9	12.58	13.43	10.58	8.67
1984	Avg.	103.3	103.7	103.9	107.7	13.05	13.43	11.07	9.04
1985	Avg.	103.7	103.2	107.6	110.9	13.38	13.74	11.56	9.46
1986	Avg.	100.0	100.2	109.6	113.9	12.46	13.48	11.98	9.65
1987	Avg.	102.6	102.8	113.6	117.7	12.52	12.98	12.37	9.88
1988	Avg.	106.3	106.9	118.3	121.7	13.24R	13.26R	12.71R	9.79R
1989	Avg.	111.6	112.2	124.0	126.6	13.59R	13.72R	13.09R	10.05R
Jan	1990	114.1	114.9	127.4	—	13.69R	13.95	13.34R	10.13R
Feb	1990	113.6	114.4	128.0	—	13.70R	13.99R	13.27R	10.16R
Mar	1990	113.2	114.2	128.7	129.7	13.80R	14.04	13.34R	10.17R
Apr	1990	113.2R	114.1R	128.9	—	13.92R	14.30R	13.53R	10.17R
May	1990	113.3	114.5	129.2		13.96R	14.16R	13.46R	10.22R
June	1990	113.1	114.2	129.9	130.9	14.00R	14.31R	13.51R	10.27R
July	1990	113.2	114.3	130.4	—	14.18P	14.49P	13.59R	10.34R
Aug	1990	115.9	116.5	131.6	—	—	—	13.56P	10.34P

P = Preliminary **R** = Revised since last month

[1] US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents. Historical data is presented in Report 233.

[2] US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items. Historical data is presented in Report 233.

[3] US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted. Historical data is presented in Report 233.

[4] US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Historical data is presented in Report 233.

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VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3] Average Price in ECU per pound U_3O_8	Medium or Long-Term Contracts[3] Average Price in US Dollars per pound U_3O_8	Spot Contracts[3] Average Price in ECU per pound U_3O_8	Spot Contracts[3] Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00
1986	12,000	9.5	ECU 31.50	$31.00	ECU 18.00	$17.75
1987	14,000	17.0	ECU 28.25	$32.50	ECU 15.00	$17.25
1988	12,500	4.5	ECU 26.92	$31.82	ECU 13.65	$16.13
1989	13,500	11.5	ECU 26.63	$29.35	ECU 11.04	$12.19

R = Revised

[1] The twelve European Community member nations are Belgium, Denmark, France, West Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EEC.

[2] The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3] For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar. Exchange rates are published by European Communities Statistical Office and the International Monetary Fund.

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GOVERNMENT STATISTICS

US URANIUM MARKETING ACTIVITIES STATISTICS
(Compiled from data published by the US Energy Information Administration) [1]

Year	Total Production (million pounds U_3O_8)	Deliveries to Domestic Utilities From US Suppliers[2] (million pounds U_3O_8)	Average Price of Delivered Uranium[2] (\$/lb. U_3O_8)	Quantity of Uranium Imported[3] (million pounds U_3O_8)	Average Price of Imported Uranium (\$/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	27.6	$16.10	3.6	n/a	1.2
1977	29.9	27.8	$19.75	5.6	n/a	4.0
1978	37.0	31.6	$21.60	5.2	n/a	6.8
1979	37.5	33.0	$23.85	3.0	n/a	6.2
1980	43.7	35.0	$28.15	3.6	$43.10	5.8
1981	38.5	32.6	$34.65	6.6	$32.90	4.4
1982	26.9	23.5	$38.37	17.1	$25.19	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3
1986	13.5	18.9	$30.01	13.5	$20.07	1.6
1987	13.0	20.8	$27.37	14.8	$19.14	1.0
1988	13.1	17.6	$25.65	15.8	$19.03	3.3

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[1] Sources: 1976-1983: US Department of Energy/Energy Information Administration, *Survey of United States Marketing Activity*
1984-1988: Energy Information Administration, *Uranium Industry Annual*

[2] Data for 1976-1981 includes both domestic utilities and agents

[3] Includes imports by domestic utilities and domestic suppliers

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INTERNATIONAL ADVISORY COMMITTEE

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South Africa

Lars Halle
Sweden

James C.C. Stewart
United Kingdom

REPRESENTATIVES

JAPAN:

Kazuo Yokota
Japan Tech Services
Ohkura Building (3F)
1–4–10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telefax: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

SOUTH AFRICA:

Chris I. Von Christierson
Southern Prospecting (Pty) Limited
Mailing Address:
Post Office Box 61409
Marshalltown 2107
Republic of South Africa
Street Address:
7th Floor, Marshall Place
66 Marshall Street
Johannesburg 2001
Telephone: (27-11) 834-4211
Telefax: (27-11) 834-6343
Telex: 4-89878-SA

TAIWAN:

Dr. Steve H.K. Wang
Southeast Engineering Corporation
Yu-Ming Mansion
7, Roosevelt Rd., Sec. 1, 7th Floor
Taipei, 10757, Taiwan R.O.C.
Telephone: (886-2) 321-0216
Telefax: (886-2) 394-2621
Telex: 11285 (SENCORP)

UNITED STATES:

Harold C. Lindberg
83-A Hardee Lane
Whispering Pines, North Carolina 28327
Telephone: (919) 949-3622
Telefax: (919) 949-2626

Ralph O. Smith
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 272-6246
Telefax: (203) 271-1346

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